Chapter 3

Overview Of Monitoring In Galveston Bay

This chapter summarizes existing monitoring efforts in the Galveston Bay Estuary upstream to the limit of tidal influence. A summary table and maps showing sampling locations for each monitoring program have been generated together with a description of that program.

The following information was requested from each of the agencies contacted:

- Monitoring Program Objectives
- Measurements Collected
- Locations of Sampling Sites
- Sampling Schedule
- Monitoring Methods
- Quality Assurance
- Data Management
- Monitoring Program Costs

Selected monitoring programs are summarized in Table 3-1, with more detail given in the following sections.

Federal Agencies:

U.S. Environmental Protection Agency

An ongoing assessment program of the USEPA is the Environmental Monitoring and Assessment Program (EMAP). USEPA EMAP goals (U.S. EPA, 1992,b) are to:

- Estimate the current status, trends, and changes in selected existing and newly-developed indicators of the condition of the Nation's ecological resources
- Estimate the distribution and extent of the Nation's ecological resources, and

TABLE 3-1. REGIONAL MONITORING ACTIVITIES IN GALVESTON BAY ESTUARY

Summary of data collection activities, monitoring parameters, analytical methods, and quality assurance/quality control methods by the various agencies/organizations monitoring in Galveston Bay Estuary.

AGENCY/ORGANIZATION (Source)	No. OF STATIONS	DATA COLLECTION ACTIVITIES	PARAMETERS MONITORED	ANALYTICAL METHODS**	DETECTION LIMITS	QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)
Texas Natural Resource Conservation Commission (TNRCC) (Kirkpatrick, 1994) (TNRCC, 1993) (TWC, 1991) (Twidwell, 1993 and 1994) (U.S EPA, 1983 and 1986)	68 stations 243 sampling activities/year	Water Column Chemistry: (see next column) Sediment: Chemistry - Ekman dredge Benthic macroinvertebrates: Peterson or Ekman dredge Nekton: Collection techniques - Hook and line, trotline - Throwline, handline - 20' minnow seine with 1/4" mesh - Gill nets - Fish traps - Trawl - Cast nets - Water intake screens Tissue - 4 preferred species - Hardhead (sea) catfish - Pinfish - Atlantic croaker - Redfish (red drum) Plankton: - Kemmerer sampler - Van Dorn sampler - Net hauls	All stations - Routine Water: Temperature, conductivity, pH dissolved oxygen (DO), salinity Conventional pollutants: Biochemical oxygen demand (BOD) Total suspended solids (TSS) Oil and grease Fecal coliform (FC) Nutrients: Orthophosphorus Nitrite - N Nitrate - N Ammonia - N Total phosphorus Chlorophyll a Pheophytin a Total organic carbon (TOC) Alkalinity Chloride Sulfate Total dissolved solids (TDS) Volatile suspended solids (VSS) Select stations: Water and Sediment: Organics - pesticides Inorganics - alkalinity, hardness major ions Metals Toxicity Organisms: nekton - tissue plankton benthos	EPA Methods (1,2) 405.1 160.2 413.1 365.2 354.1 352.1 350.1 365.1 415.1 310.1 325.3 375.4 160.1 624 608/8080 ICP - 6010	 1 mg/l 10 mg/l 5 mg/l 0.01 mg/l 0.01 mg/l 0.01 mg/l 0.02 mg/l 0.01 mg/l 1 mg/l 1 mg/l 1 mg/l 10 mg/l 10 mg/l variable variable	TNRCC requires that a minimum of one water quality monitoring program and one water quality sampling program undergo a quality assurance review each fiscal year. Projects: - water quality monitoring field data notebook - standard instrument calibration and notebook - flow measurement records - fecal coliform bacteria analysis records - biological sample analysis records - proper data and sample collection procedures - quality assurance review follow-up Laboratory analysis will meet or exceed the requirements set forth in the TNRCC Quality Assurance program (3) Data storage: - side by side data comparisons - computerized parameter value editing
Texas Water Development Board (TWDB) (Brock, 1993 and 1994)	5 Stations supports TCOON 8 Stations	Semi-permanent moored stations using Data Sonde instrumentation Tide monitoring stations within Galveston Bay	Water: Temperature, salinity, pH conductivity, DO Tidal elevation Some meteorological data			Instruments are checked and maintained on a regular basis. NOAA / NOS QA procedures Data inspected daily

TABLE 3-1. REGIONAL MONITORING ACTIVITIES IN GALVESTON BAY ESTUARY (continued)

AGENCY/ORGANIZATION (Source)	No. OF STATIONS	DATA COLLECTION ACTIVITIES	PARAMETERS MONITORED	ANALYTICAL METHODS**	DETECTION LIMITS	QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)
Texas Parks and Wildlife Department (TPWD)						
1. Resource Monitoring (Bowling and Benefield, 1993) (Robinson, 1994) (TPWD, 1993a)	149 Stations Bay and Offshore Randomly selected from TPWD's grid system The number of usable grids varies for each gear type	Bay Bag Seines: 20 per month Targets juvenile finfish and shellfish 321 usable grids Bay Trawls: 20 per month Targets juvenile and some adult finfish & shellfish 10-minute trawls 369 usable grids ICWW (Intercoastal Waterway) Trawls: 6 per month Targets juvenile and some adult finfish & shellfish 10-minute trawls 77 usable grids Gulf Trawls: 16 per month Targets juvenile and some adult finfish & shellfish 10-minute trawls Oyster Dredges: 30 per month Targets oysters: market, small, and spat 30-second dredge - 126 usable grids Beach Seines: May - November - 6 per month Targets adults in surf zone of front beach Beach Bag Seines: May - November - 6 per month Targets juvenile finfish and shell fish in surf zone Gill nets: 45 nets set during a 10-week period in the spring and fall Targets adult finfish in bay 4 segments of 150' each, 4 mesh sizes - 3" - 6" 1 per segment, shoreline to Gulf 252 usable grids Hook and line: As required by special study	Water: Temperature, salinity, pH turbidity, DO Weather conditions Wind direction Air temperature Organisms: Species Number Weight (select individuals) Length (subsample of 19 ind.) Sex and maturity Large, live fish tagged for growth and mortality			Guidelines follow TPWD Marine Resource Monitoring Operations Manual (4) Gill nets must be set within 1/2 hour of sunset and picked up no earlier than 1/2 hour before sunrise. Work on the last net must start before 11:00 a.m. Field data sheets are edited prior to submission for computer keying Computer printouts of field data are contrasted with field data sheets after computer keying
2. Coastal Resource Harvest Commercial Landings Program (McEachron, Campell, and Robinson, 1993) (Robinson, 1994) (TPWD, 1989)	130 - 140 seafood dealers Vessel captains	Seafood dealer submits reports - pertaining to commercial finfish, shrimp, crabs, oyster, and other marine life Length checks of target species - (200 per species) 5 target species - black drum, flounder, mackerel, red snapper, sheepshead Commercial bay/bait intercept program was implemented in May 1994 On-site interviews of vessel captains	Organism: Quantity by weight Number of species Price per pound Trip length Number of drags Total fishing time Minor bay fished Net size Mesh size Amount of live and dead shrimp landed Size of shrimp Species of catch			Guidelines follow TPWD Commercial Harvest Field Operations Manual (5)

TABLE 3-1. REGIONAL MONITORING ACTIVITIES IN GALVESTON BAY ESTUARY (continued)

AGENCY/ORGANIZATION (Source)	No. OF STATIONS	DATA COLLECTION ACTIVITIES	PARAMETERS MONITORED	ANALYTICAL METHODS**	DETECTION LIMITS	QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)
3. Coastal Resource Harvest Recreational Landings Program (Robinson, Green, and McEachron, 1993) (Robinson, 1994) (TPWD, 1993b)	121 Sample sites 40 additional sites for detecting any change in status Sampling stratified and based on relative fishing pressure at each site. Determined by a computer generated relative pressure system.	On-site trip-end Interviews	Boat registration number Trip length Number of people / residency Minor bay fished Gear: Bait - type and amount Fish landed: Species Total lengths (6 per species) Grade Species sought By-catch - released Trip satisfaction			Interviewers are periodically observed to monitor compliance with operating procedures Guidelines follow TPWD Marine Sport Harvest Operations Manual (6)
City of Houston/Department of Public Works & Engineering (CoH PW&E) (Glanton, 1993)	45 Stations in the tidal portions of major bayous		Water: probe Temperature, pH, conductivity, DO Total Residual Chlorine (TRC) Ammonia - N Nitrate - N BOD TSS FC			
City of Houston/Health and Human Services Department (HHSD) (APHA, 1992) (Fisher, 1993 and 1994) (Krentz, 1993) (U.S. EPA, 1983)	Field Operations : - 54 stream stations - all permitted wastewater dischargers	CoH - HHSD - The Bureau of Public Health Engineering has two groups conducting monitoring Field Operations Unit - Stations are all above tidal waters	Water: probe Temperature, DO	EPA Methods (1)		Participate in APG proficiency studies twice each year for each analyte listed (chemistry) Field Notes, information reviewed after computer entry
			BOD	405.1	4 mg/l	Duplicate
			Ammonia-N	350.1	0.05 mg/l	Duplicate, spike, external QC
			Sulfate	300	2 mg/l	Duplicate, spike, external QC
			TDS	160.1	20 mg/l	Duplicate
			TSS	160.2	4 mg/l	Duplicate
			Oil and grease	413.1	1 mg/l	External QC
			Chloride	300	2 mg/l	Duplicate, spike, external QC
			Trace metals:			
			As	206.2	2 mg/l	Duplicate, spike, external QC
			Cd, Cr, Du, Mn, Zn	200.7	10 mg/l	Duplicate, spike, external QC
			Ni	200.7	25 mg/l	Duplicate, spike, external QC
			Se	200.7	1 mg/l	Duplicate, spike, external QC
			Hg	245.2	0.5 mg/l	Duplicate, spike, external QC
			Pb	200.7 / 239.2	40 mg/l	Duplicate, spike, external QC
			FC	Standard Methods (7) 9221 E(1.)	2 / 100 ml	FC bacterial analysis records 9221 E(1.)
	Quality Assurance Group : - Lake Houston and watershed - 6 major Houston bayous	Quality Assurance Group - These bayou stations are all at USGS monitoring stations and include the lowest USGS station at each bayou	Water: probe Temperature, DO	EPA Methods (1)		Field notes, information reviewed after computer entry
			pH	150.1		Buffer check
			TDS	160.1	20 mg/l	Duplicate
			Sulfate	300	2 mg/l	Duplicate, spike, external QC
			Chloride	300	2 mg/l	Duplicate, spike, external QC
			FC	Standard Methods (7) 9221 E(1.)	2 / 100 ml	Standard Methods (7) FC bacterial analysis records

TABLE 3-1. REGIONAL MONITORING ACTIVITIES IN GALVESTON BAY ESTUARY (continued)

AGENCY/ORGANIZATION (Source)	No. OF STATIONS	DATA COLLECTION ACTIVITIES	PARAMETERS MONITORED	ANALYTICAL METHODS**	DETECTION LIMITS	QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)
Harris County Pollution Control Department (HCPCD) (APHA, 1992) (Barrett, 1993 and 1994) (Tyer, 1994)	9 Stations - Houston Ship Channel 6 Stations - on the San Jacinto River Each industrial discharger Municipal dischargers		Water: probe Temperature, DO, flow	Standard Methods (7) DO = 4500-0 G		Calibrate meter prior to each use
			pH	4500-H+		2 buffer standardization and read 3rd buffer prior to each analytical run; restandardize/ reanalyze violations
			TOC	5310B	1 mg/l	Standardize prior to each analytical run (optional: check calibration with independent standard), check calibration about every 10 samples and at end of run. Reanalyze violations, including spike analysis
			Trace metals: As Cd Cr, Ni Cu, Mn Zn	 3111/3113 3111 3111 3111 3111	 0.001 mg/l 0.002 mg/l 0.02 mg/l 0.01 mg/l 0.005 mg/l	Two point calibration prior to each analytical run; check calibration about every 10 samples. One replicate analyzed with each run. Reanalyze violations, including spike analysis.
			Total solids (residue)	2540B		Control dish (no sample)
			TSS	2540D		One random replicate with each analytical run and/or replicates on any suspected violations; reanalyze any violation without previous replicate; water blank and control crucible (no sample) with each run
			Ammonia - N	4500	0.03 mg/l	Standardize prior to each analytical run; one random replicate analyzed with each run; check calibration with two different standards (concentrations) one during run and other at end of run
			FC/Fecal Streptococcus (FS)	Modified 9222D/9230C	10 / 100 ml	Periodically analyze replicates, system blank, air density plate and known active sewage
			Volatile acids (VA)	Qualitative		Periodically analyze known cyanide solutions
			Sulfide	Qualitative		Periodically analyze known sulfide solutions
			Chloride	Harris County Method	7 mg/l	Periodically analyze chloride standard
Galveston County Health District Pollution Control Division (GCHD) (APHA, 1989) (Fogerty, 1993 and 1994) (Wright, 1994)	120 Stations including Galveston Island - beach, bayside, ship channel, and bayous Mainland county bayous, creeks, some drainage ditches Texas City Ship Channel and Dike	Collect water quality samples only Grab samples usually, composites rarely Samples collected on monthly, bi-monthly, and tri-annual basis	Date and time Wind direction Wind speed Cloud cover Rainfall Days prior rainfall and amount Tide (high/low) Flow direction (in/out) Sample depth Air temperature Water temperature	 Use NOAA weather information for: wind direction, speed, and rainfall Use daily rainfall data from wastewater treatment plants throughout county		Field meters are calibrated using manufacturers guidelines before each use. Manufacturer services meters as necessary. Laboratory uses standard QC methods (blanks, spikes, controls, and duplicates) EPA required controls implemented for those tests performed for contracted services for cities

TABLE 3-1. REGIONAL MONITORING ACTIVITIES IN GALVESTON BAY ESTUARY (continued)

AGENCY/ORGANIZATION (Source)	No. OF STATIONS	DATA COLLECTION ACTIVITIES	PARAMETERS MONITORED	ANALYTICAL METHODS**	DETECTION LIMITS	QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)
	Permitted dischargers Complaint sampling		DO, salinity, conductivity pH Water color Observed turbidity or secchi disc BOD TSS FC Occasionally: Chemical oxygen demand (COD) Ammonia-N Total phosphorus Oil and grease Extra capabilities: TDS Volatile suspended solids (VSS) orthophosphate	YSI field meters Corning or Orion meters 4500-H Standard methods Standard Methods (8) 5210 B 2540-D 5220 B 4500 NH3 B 4500-P-B-5 5520 B 2540-C 2540-E 4500-P-B	2 mg/l 0.01 mg/l 0.02 mg/l 0.01 mg/l	4500-H Standard metho Standard Methods (8)
Chambers County Environmental Health Department (Jackson, 1994)	Trinity Bay - respond to septic/ sewage complaints Lake Anuhuac	No monitoring programs in Galveston Bay	FC			
U.S. Environmental Protection Agency (EPA) Environmental Monitoring and Assessment Program (EMAP) (Heitmuller and Valente, 1991) (Hornig, 1993) (Summers et al., 1992) (U.S. EPA, 1983 and 1991)	5 Stations in the vacinity of 5 marinas 6 Stations in East Bay Bayou	Water quality - two models of dataloggers - Surveyor II - instantaneous measurements - Data Sonde 3 - continuous measurements Water clarity - LICOR L1-1000 containing a submersible light sensor Light penetration - Secchi disk Fish: Trawling with a 16', high rise otter trawl with a 2.5 cm mesh cod end - towed for 10 minutes against tide Target species for tissue contaminants: - shrimp (brown and white) - Atlantic croaker - catfish (hardhead, gafftopsail, and blue) Composite of 4 - 10 individuals per site Bivalves: Modified oyster dredge with collection bag towed over the bottom - 5 minutes at approximately 1 m/s	Water: probe Temperature, salinity, pH, DO Water clarity Water depth Light Marine debris Fish: Number of species Total abundance Gross pathology Bivalves: Total abundance Species composition Shell length Fish and bivalve tissue: Pesticides, PCBs Heavy metals Benthic community parameters Grain-size analyses			Crew training and sample collection: - chief training - crew training - field certification / auditing - testing and scoring of personnel Water quality measurements: Field quality control checks - instantaneous and continuous measurements - All datalogging units are calibrated with documentation within the 24-hour period preceding their scheduled use - side by side measurements between Data sonde and Surveyer (standard) - QC data compiled and evaluated to determine the frequency of acceptable and unacceptable adherence to QA guidelines Laboratory certification and chemical analyses: - laboratories must pass a certificaiton prior to analyzing any samples - usual QC methods (blanks, spikes, controls, and duplicates) - standard reference materials (SRMs) with certified values for metals and organics

TABLE 3-1. REGIONAL MONITORING ACTIVITIES IN GALVESTON BAY ESTUARY (continued)

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		Benthos: Young - modified Van Veen grab which samples a surface area of 440 square cm - 3 grabs at base, index, or supplement sites - 5 grabs at indicator sites Grain-size analyses: *Small core (60 cc) from each grab - sieved*	Sediment: Toxicity Ampelisca abdita Mysidopsis bahia Alkanes and isoprenoids PAHs Pesticides, PCBs Heavy Metals: Ag, Al, Cr, Cu, Fe, Mn, Ni, Pb, An As, Cd, Sb, Se, Sn Hg Butyltins TOC	 10-day acute bioassay 4-day acute bioassay GC/MS GC/ECD ICP-AES ICP-AES GFAA CVAA		Laboratory testing and analyses: - scheduled recounts and resorts for benthic assessments - experimental controls for sediment toxicity testing - scheduled replication for sediment characterization - use of blank, spikes, and standards *for chemical assessments* - EMAP-E personnel visit each of the laboratories at least once while EMAP-E analyses is occurring
R-EMAP-TX program	33 Stations - 29 systematic grid sites - 4 randomly selected bay sites		Sediment: Detailed chemistry Benthic communities			
U.S. Geological Survey (USGS) (Fisher, 1994) (Liscum, 1993)	2 stage gages 4 automatic monitoring stations 12 stations	USGS - stage gage - Moses Lake - stage gage - Hwy 90 at San Jacinto River Freshwater inflow monitoring	stage and precipitation stage Water: probe Temperature, salinity, pH conductivity Surface water elevation Surface water elevation - hourly Freshwater inflow - hourly 4 to 6 samples per year BOD COD FC FS TOC Nutrients Selected pesticides/herbicides Specific conductance Water temperature			Instruments are checked, maintained, and calibrated on a regular basis
Galveston Bay Foundation (GBF)	Approximately 34 stations in tidal segments	Grab samples are taken 1 foot below surface Samples are collected weekly or bi-monthly	Water: temperature, DO, pH, salinity, conductivity, turbidity Weather: wind direction, intensity, days since last rainfall, air temp. Other: total depth, water level, odor, site observations, tide, color	Standard Methods: 2550-B. 4500-o C 4500-H B 2510 B		GBF follows the Texas Watch QAPjP; Monitors receive Texas Watch (TNRCC) training Monitors participate in 2 QC sessions per year. Conductivity pens are calibrated prior to each monitoring event. DO chemicals are changed every 6 months.

TABLE 3-1. REGIONAL MONITORING ACTIVITIES IN GALVESTON BAY ESTUARY (continued)

AGENCY/ORGANIZATION (Source)	No. OF STATIONS	DATA COLLECTION ACTIVITIES	PARAMETERS MONITORED	ANALYTICAL METHODS**	DETECTION LIMITS	QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)
U.S. Fish and Wildlife Service (USFWS)	Entire estuary - every 10 years	USFWS - National Wetlands Inventory - program of mapping wetlands using aerial photography	Vegetation groups:	Photo analysis Ground truthing		
(Special Study) Galveston Bay National Estuary Program (GBNEP) (Carr, 1993) (Jensen et al., 1993)	24 Stations 16 stations selected in depositional zones away from known point source discharges 8 stations selected based on specific areas of concern A GPS navigation receiver was used to determine station locations.	Sediment: - collected with a 4" diameter coring device Benthos: - collected with a 2" diameter coring device	Water: probe Temperature, salinity Water depth Sediment: Trace metals: Al, Br, Be, Cr, Cu, Fe, Mg, Mn, Ni, Tr, Vd, Zn As, Cd, Pb, Se Hg PAHs Pesticides, PCBs TOC AVS Toxicity: *Grandidieralla japonica* Pore water: DO, pH, hydrogen sulfide Temperature, ammonia Toxicity: gametes Arbacia punctulata Benthic community parameters Total abundance Species composition Species diversity Species richness	DCP DCP GFAA CVAA MS in the SIM mode CGC oulometer TOC analyzer GFAA 10-day solid-phase bioassay Fertilization test Morphological development assay		NS&T QA/QC Procedures Morphological development assay
National Oceanic and Atmospheric Administration (NOAA) National Status and Trends Program (NS&T) (Presley and O'Conner, 1993)						NS&T Program Methodology - performance based Analysis of reference materials and control materials is required

TABLE 3-1. REGIONAL MONITORING ACTIVITIES IN GALVESTON BAY ESTUARY (continued)

AGENCY/ORGANIZATION (Source)	No. OF STATIONS	DATA COLLECTION ACTIVITIES	PARAMETERS MONITORED	ANALYTICAL METHODS**	DETECTION LIMITS	QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)
1. National Benthic Surveillance Project (NBSP) (NOAA, 1993)	9 Stations : a nominal site center has been defined for NBSP sites as an area 2 km in diameter and is revisited for sample collection	Sediments were collected concurrently with fish specimens at each NBSP site Sediment: - specially constructed box corer - standard Smith-MacIntyre bottom grab the water was drained before sediment was take Fish: - primarily collected by otter trawls towed by NOAA vessels - occasionally by hook and line or gill nets	Sediments: Organic compounds: Pesticides, PCBs PAHs Coprostanol Major and trace elements: Sl, Al, Fe Cr, Zn, Mn Ag, As, Cd, Cu, Ni, Pb Hg Clostridium perfringens TOC Moisture content Particle size Fish Tissue: Organic compounds: Pesticides, PCBs PAHs - stomach contents PAH metabolites - bile Major and Trace elements: Al, Ag, As, Cd, Cr, Ni, Pb, Sb, Se, Sn, Tl Fe, Mn, Cu, Zn Hg Tissue dry weight Otoliths or scales - fish age	 GC/ECD GC/FID/MS GC/FID FAA FAA, GFAA GFAA, FAA, HAA CVAA plate count CHN analyzer drying at 120 degrees C Wet sieving techniques GC/ECD GC/FID/MS HPLC/FID GFAA GFAA FAA CVAA Oven drying	 0.0001 ug/g 0.0010 ug/g Ag, Cd, Hg = 0.005 ug/g Cr, Pb = 0.2 ug/g As, Cu = 0.05 ug/g 0.001 ug/g 0.01 ug/g 0.01 ug/g Ag, Cd, Hg = 0.001 ug/g Cr, Pb = 0.04 ug/g As, Cu = 0.01 ug/g	Trace organic analytical procedures - internal standards are added at the start and carried through analyses Calibration checks - plus or minus 10% of the accuracy based value for standards All samples must be quantified within the calibration range Method Detection Limits (MDLs) are calculated and reported annually - Since 1989, method for calculating MDLs is that used by the EPA If EPA method is not used - the procedure is described in detail Precision - defined limits Accuracy - defined limits A minimum of 8% of an analytical sample string should consist of blanks, reference or control materials, duplicates, and spike matrix samples Data acceptability criteria reported annually Intercomparison exercises Quality assurance workshops Development of standard reference and 0.01 ug/g control materials
2. Mussel Watch Program (MWP) (NOAA, 1993)	6 Stations: Sites were defined using Global Positioning System Technology	When taken, sediment samples were collected concurrently with bivalve samples Sediments: - stainless steel box core - Teflon-coated sampling scoop Oysters: American oyster - hand (preferred), tongs, or dredge	Water: probe Temperature, salinity, depth Sediments: Organic compounds: Pesticides, PCBs PAHs Coprostanol Major and trace elements: Al, Cr, Mn, Fe Ni, As, Se, Ag, Cd, Sn, Pb Cu Zn Hg Clostridium perfringens TOC Moisture content Particle size Oyster tissue: Organic compounds: Pesticides, PCBs PAHs	 GC/ECD GC/MS GC/FID NAA GFAA GFAA, FAA FAA CVAA plate count carbon analyzer 4 hours at 45 degrees C Dry sieved GC/ECD GC/MS	 0.0001 ug/g 0.0010 ug/g Ag, Cd, Hg = 0.005 ug/g Cr, Pb = 0.2 ug/g As, Cu = 0.05 ug/g 0.001 ug/g 0.01 ug/g	National Institute of Standards and Technology (NIST) trace organic exercises - performance based National Research Council (NRC) trace element exercises - performance based

TABLE 3-1. REGIONAL MONITORING ACTIVITIES IN GALVESTON BAY ESTUARY (continued)

AGENCY/ORGANIZATION (Source)	No. OF STATIONS	DATA COLLECTION ACTIVITIES	PARAMETERS MONITORED	ANALYTICAL METHODS**	DETECTION LIMITS	QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)
			Major and trace elements: Al, Mn, Fe, Zn Cu Cr, Ni, As, Se, Ag, Cd, Sn, Pb Hg Tissue dry weight Shell size Radionuclide samples - 1991 Gonadal index	 FAA FAA/GFAA GFAA CVAA Oven drying	Ag, Cd, Hg = 0.001 ug/g Cr, Pb = 0.04 ug/g As, Cu = 0.01 ug/g	 0.01 ug/g
National Marine and Fishery Service (NMFS) (Zimmerman, 1993)						
1. Baseline Production	Variable stations in West Bay marsh	Fish, shrimp, and crabs are sampled using drop samplers	Organisms: Densities of target species Biomass			
2. Brown Shrimp Catch Program		NMFS - brown shrimp - Interviews with bait dealers and fishermen - Reviews of fishermen's logs	Catch per unit effort Pounds per hour			
3. Post Larval Shrimp Program (discontinued in 1993)	6 Stations	Samples are collected with a 5' long, small-meshed, modified hand-held beam trawl	Water: probe Temperature, salinity Tide condition Catch per 100 square meters of bottom area Length (size of shrimp)			
Texas Department of Health (TDH) (APHA, 1970) (Wiles, 1993)	104 Stations - approved shellfish harvest areas - conditionally approved waters	Water samples are collected 2 feet under the water surface while other parameters are measured by probes.	Water: probe Temperature, DO, salinity Weather conditions: Air temperature Rainfall Wind direction Wind velocity Tide conditions FC			National Shellfish Sanitation Program NSSP QA/QC Guidelines (9)

TABLE 3-1. REGIONAL MONITORING ACTIVITIES IN GALVESTON BAY ESTUARY (continued)

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U.S. Army Corps of Engineers (USCE) 1. Dredged Material Monitoring Program Galveston District (Medina, Hauch, and Arhelger, 1993) (U.S. EPA, 1986 and 1991)	6 core stations in the Houston Ship Channel	Samples collected by a bottom grab	Heavy Metals As Cd Cr Cu Ni Pb Zn Se Hg Oil and grease PCBs PAHs Pesticides Grain-size analyses Toxicity Bioaccumulation	EPA methods (2) 7060 7131 7191 7211 7521 7421 7951 7740 7470 -day solid phase bioassay 28-day bioaccumulation		Dredged Material Testing Manual (2) EPA methods (2) QA/QC Guidelines (10) - 10% of laboratory samples are field duplicates - One sample of every 10 - 20 samples are analyzed in triplicate
2. Open Bay Disposal Dredged Material Program - Waterways Experiment Station (3 year program scheduled to finish in 1994) (Clark and Ray, 1993) (U.S. EPA, 1986 and 1991)	30 Stations: Open Bay	Samples collected with a box corer Sediment profiler	Sediment: Sediment profile imagery Grain-size analyses Sediment carbon Redox potential Surface relief Benthos parameters	EPA methods (2)		Dredged Material Testing Manual QA/QC Guidelines (10)

NOTES:

(1) U.S. EPA. 1983. Methods for chemical analyses of water and wastes, 2nd Edition. EPA 600/4-79-020. U.S. Environmental Protection Agency, Environmental Support Laboratory.
(2) U.S. EPA. 1986. Test Methods for Evaluating Solid Wastes, 3rd Edition. EPA SW-846. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.
(3) TNRCC. 1993. Quality Assurance Project Plan for Environmental Monitoring and Measurement Activities, Surface Water Monitoring. Texas Natural Resource Conservation Commission, September 1993.
(4) TPWD. 1993a. Marine Resource Monitoring Operations Manual. Texas Parks and Wildlife Department, January 1993.
(5) TPWD. 1989. Commercial Harvest Field Operations Manual. Texas Parks and Wildlife Department, January 1989.
(6) TPWD. 1993b. Marine Sport Harvest Monitoring Operations Manual. Texas Parks and Wildlife Department, July 1993.
(7) APHA. 1992. Standard Methods for the Examination of Water and Wastewater, 18th Edition. American Public Health Association, Washington, D.C.
(8) APHA. 1989. Standard Methods for the Examination of Water and Wastewater, 17th Edition. American Public Health Association, Washington, D.C.
(9) APHA. 1970. Recommended Procedures for the Examination of Seawater and Shellfish. American Public Health Association, Washington, D.C.
(10) U.S. EPA. 1991. The Near Coastal Laboratory Procedures Manual. Environmental Monitoring and Assessment Program. U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Cincinnati, OH.

**** ABBREVIATIONS:**

AES - Atomic emission spectrometry
CGC - Capillary gas chromatography
CHN analyzer - Carbon-hydrogen-nitrogen analyzer
CVAA - Cold vapor atomic absorption
DCP - Direct coupled plasma
ECD - Electron capture detection
FAA - Flame atomic absorption
FID - Flame ionization detector
GC - Gas chromatography
GC - Gas chromatography
GFAA - Graphite furnace atomic absorption
HAA - Hydride generation atomic absorption
HPLC - High performance liquid chromatography
ICP - Inductively coupled plasma
MS - Mass spectrometry
NAA - Neutron activation analysis
SIM - Selected ion monitoring

- Seek associations between selected indicators of natural and human stresses and indicators of the condition of ecological resources.

Sampling stations are systematically distributed throughout the estuary according to gridded areas — approximately 18 km between each sampling station. A quarter of these gridded areas are sampled every year. During each sampling event, a random sample station is located within those grids to be sampled. All samples are collected in the summer generally August to September. EMAP-E indicators focus on fish and benthic community structure, contaminant levels in fish and sediment samples, sediment toxicity, and dissolved oxygen profiles.

In addition to EMAP-E the EPA has conducted higher resolution sampling in Galveston Bay under the Regional-EMAP (R-EMAP) . The purpose of the R-EMAP pilot program for Galveston Bay was to follow-up on areas flagged during previous EMAP-E sampling. R-EMAP projects will also demonstrate the utility of applying EMAP design and indicator concepts to address problems of a smaller spatial and temporal scale. Sediment collection and analyses followed EMAP Near Coastal protocols. Analyses of sediment chemistry, sediment toxicology, and benthic community structure were conducted. The project will initially be limited to one round of sampling, conducted in mid-September 1993. The decision to conduct a follow-up of the project will be made after examination of the data. The proposed cost of the program is approximately $250,000. (K. Summers, U.S. EPA, personal communication)

The R-EMAP pilot project for Galveston Bay consisted of randomly sampling 33 stations uniformly distributed about the bay (Figure 3-1) Bottom sediment samples were collected from the 29 grid and 4 bay stations for detailed chemistry and benthic community analyses. Three duplicate samples are randomly selected from the grid site samples for chemistry analysis and as a quality assurance practice. Five marina stations were sampled for sediment chemistry, benthic communities, and water Tri-Butyl-Tin (TBT) analysis. The six East Bay Bayou stations were sampled for 1) fish tissue pathology and chemistry and for 2) sediment chemistry and toxicity analyses. One additional fish chemistry analysis is also conducted as a quality assurance practice.

United States Geological Survey

USGS operates a total of 16 stations which monitor water quality in either tidally affected sections of Galveston Bay or freshwater inflow to the Bay (F. Liscum, USGS, personal communication). These stations include four continuous four-parameter monitors operated for the City of Houston located on tidally influenced reaches (Buffalo Bayou at the Turning Basin, Buffalo Bayou at McKee St. (just below the confluence with White Oak Bayou), Buffalo Bayou at Shepherd Drive, and White Oak Bayou (just above the confluence with Buffalo Bayou). Continuous monitoring parameters are water-surface elevation, temperature, dissolved oxygen and specific conductance. These data are available on a near real-time basis

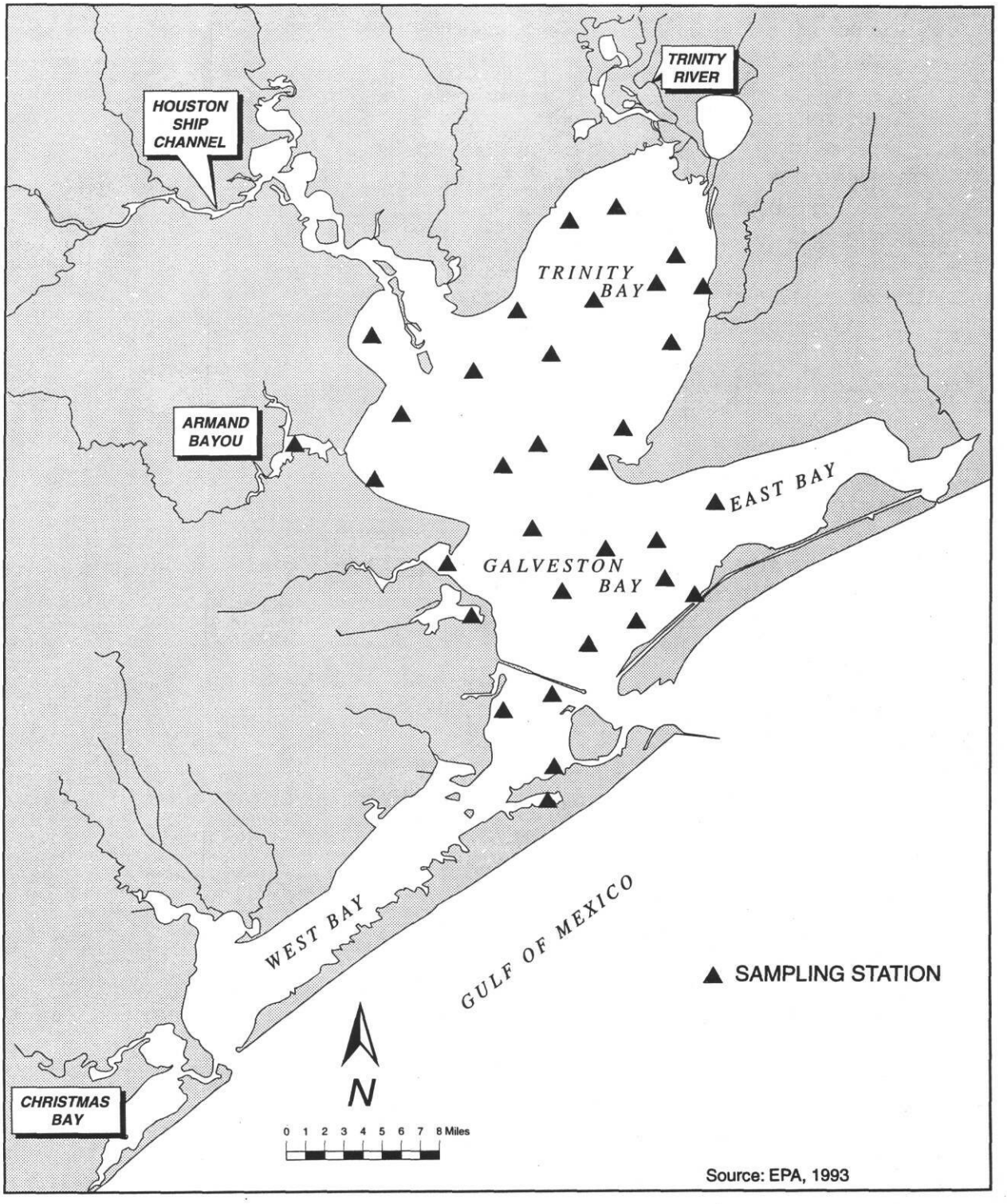


Figure 3-1. U.S. EMAP sampling stations in Galveston Bay.

through access via the GOES satellite system. Annual cost (1994 FY) for each station is about $26,500.

The twelve other stations are located to help define freshwater inflow to Galveston Bay. These include four sites to better define the impacts from the urban areas of Houston (located on the Brays, Sims, Hunting and Greens Bayous), seven sites to define the contribution from Lake Houston (sites located on Lake Houston and six tributaries, Cypress Creek, Spring Creek, Luce Bayou, West Fork San Jacinto River, Caney Creek and East Fork San Jacinto River) and one site to help define the input from the Trinity River (located at Romayor). These sites are paired with USGS flow stations and are equipped with automatic samplers. In addition to hourly water surface elevation and flow data, the following data are available for these sites for collected samples:

> BOD, CBOD, FC, FS, TOC, minor elements (calcium, magnesium, alkalinity, sulfate etc.), nutrients, selected herbicides and pesticides, specific conductance and water temperature.

Sample collection frequency varies in the order of 4 to 6 times a year, depending upon agency requirements. The cost for operating these stations ranges from about $15,000 to almost $25,000, dependent on the sampling frequency.

The recorded data from USGS stations are available in the Water Resources Data Reports publications series. These data are also available by other sources from USGS:

1) Through NAWDEX, i.e., main frame access to USGS archives and on-line data storage. TNRIS is the assigned access point for Texas.

2) Hard copy (i.e., printouts) and/or computer compatible media requests are available by written request.

3) Access over computer communication networks are available by entering into an agreement with USGS (MOU - Memorandum of Understanding).

None of the monitoring stations fall within the boundaries of the base map used in this chapter. These will be critical stations in the tributary monitoring effort.

United States Corps of Engineers

The U.S. Corps of Engineers is presently conducting two sampling programs in Galveston Bay. The first is the Dredged Material Monitoring Program by USCE Galveston District (R. Medina, R. Hauck, and M. Arhelger, U.S. Army Corps of Engineers, Galveston District, personal communication). As shown in Figure 3-2, six stations in the Houston Ship Channel are regularly monitored for dredging

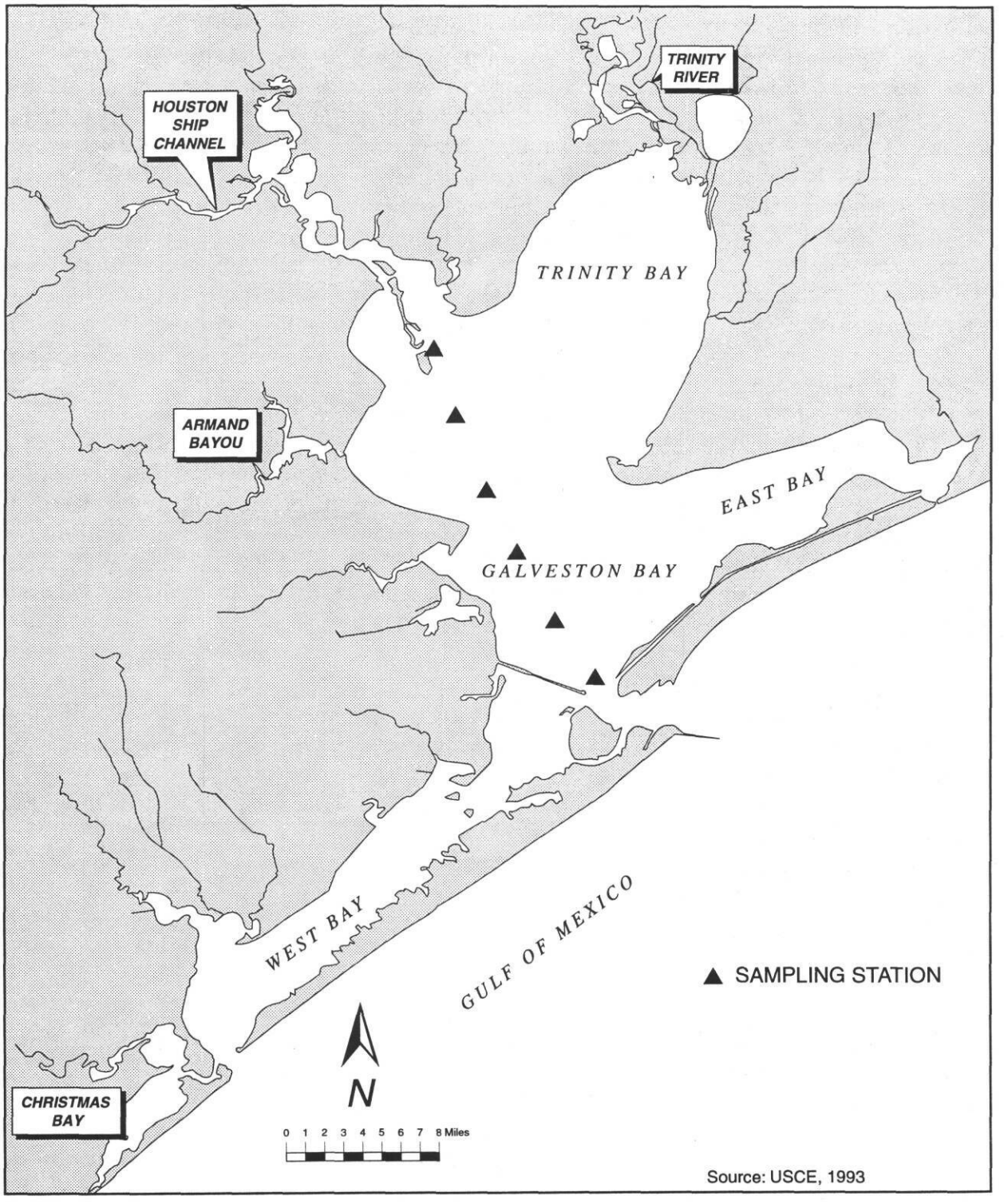


Figure 3-2. USCE Galveston District Houston Ship Channel "core" monitoring stations.

activities. Other estuarine stations are also monitored for specific projects. All channels currently being dredged are sampled once before dredging and six times after dredging. Maintained channels are monitored every three years. Samples are collected by bottom grab and analyzed for metals, oil and grease, PCBs, PAHs, pesticides, grain sizes, toxicity, and bioaccumulation. The collected data are not stored at USCE but are retained by a private contractor. The annual cost for the monitoring program is variable depending on the number of dredgings conducted in one year. However, the cost per sampling effort is approximately $76,000.

The second USCE sampling program in Galveston Bay is the Open Bay Disposal Dredge Material Program conducted by the Waterways Experiment Station (D. Clarke and G. Ray, U.S. Army Corps of Engineers, Waterways Experiment Station, personal communication). This is a three-year research program, now in its final year. Thirty stations are monitored two to four times per year. Sixteen stations are located in the upper bay areas. Fourteen are located in the lower bay areas. The monitoring is conducted by box corer and sediment profiler for sediment profile imagery, benthos characterization, grain size, sediment carbon, Redox potential, surface relief, and benthic succession. The collected data are stored in an in-house computer. While this program is not an ongoing monitoring program, it is mentioned here because of the valuable information that will be provided for bay sediments.

United States Fish and Wildlife Service

The USFWS does not conduct a routine monitoring program such as the TNRCC or USGS programs (B. Cain, USFWS, personal communication). USFWS activities are generally limited to short-term special studies to address particular issues. The USFWS does carry out the National Wetlands Inventory (NWI), which is a program of mapping wetlands nationwide using stereoscopic analysis of high altitude aerial photography and historical topographic data. Areal changes in open-water, wetlands, and developed land are assessed and future changes projected. This survey is performed at a roughly 10-year interval. The last NWI survey/projection for Galveston Bay was funded as a GBNEP characterization project (White et al., 1993).

USFWS is also involved with several bird surveys. The Mid-winter Waterfowl Survey is conducted in cooperation with the Texas Parks and Wildlife Department. This survey consists of a systematic scheme of sampling along transects and another less systematic scheme of counting birds in general locations. These data provide information on abundance of waterfowl by species and by transect, or by general location within the surrounding waters of Galveston Bay System (Slack, 1992). Another bird data set important to the GBRMP monitoring effort is the Shorebird Survey of Bolivar Flats. The USFWS has conducted irregular monthly surveys since 1980 at the Bolivar Flats. These surveys are conducted in the beach and marsh habitats of the flats by one observer using a spotting scope to identify all species of birds (Slack, 1992).

Plans for monitoring wildlife refugees are being developed. This effort is expected to fall under the responsibility of the recently created National Biological Survey. At this time no specific plans or schedules have been developed for Galveston Bay. Occasional special studies are performed by USFWS, but these cannot be considered monitoring efforts (B. Cain, USFWS, personal communication).

National Oceanographic and Atmospheric Administration

The NOAA has two programs that involve monitoring activities in Galveston Bay (R. Presley and T. O'Connor, National Oceanic and Atmospheric Administration, personal communication). The first is the Mussel Watch Program, which monitors six stations in Galveston Bay, as shown in Figure 3-3. Oysters are sampled annually for the measurements of trace elements, chlorinated pesticides, polychlorinated biphenyls (PCBs), PAHs, and TBT. Sediments were also sampled during the period from 1986 to 1988. The collected data are stored in a NS&T database in spreadsheet (Excel) or ASCII formats. The cost of the program is $10,000 per site per year or $60,000 per year.

The second NOAA monitoring program is the National Benthic Surveillance Project, which monitors nine sites in Galveston Bay, as shown in Figure 3-3. Fish are sampled from the sites once every two years. Fish tissues are analyzed for organic compounds, chlorinated pesticides, PCBs, PAHs, and pathology of fish livers are measured. Sediments are also sampled for trace metals, organic compounds, pesticides, PCBs, and PAHs. The collected data are stored in a NS&T database in spreadsheet (Excel) or ASCII formats. The cost of the program is $10,000 per site per year or $90,000 per year.

National Marine Fisheries Service

The NMFS has two operational monitoring programs in Galveston Bay. The first is the Brown Shrimp Bait Survey. Bait dealers and fishermen are interviewed, and fishermen logs are reviewed, weekly from April through June to gather catch per unit effort data (i.e., pounds per hour) for juvenile penaeid shrimp. The second program is the Jamaica Beach Program, in which fish and decapod crustacean populations are monitored using drop sampler collections at several salt marsh sites in West Bay near Galveston Island State Park. Sixteen (8 pairs) of vegetated and unvegetated samples were collected monthly from 1982 through 1992. Since 1992, this monitoring program has been scaled back, monthly samples were collected January-July in 1993 and March-May in 1994. Data from these monitoring programs are stored on computer files at the Galveston Lab. No cost or data management information is available for these programs at this time (L. Rozas, NMFS, personal communication).

State Agencies:

Texas Natural Resource Conservation Commission

The TNRCC conducts routine sampling in Galveston Bay to maintain a central database for monitoring water and sediment conditions. The measurements include

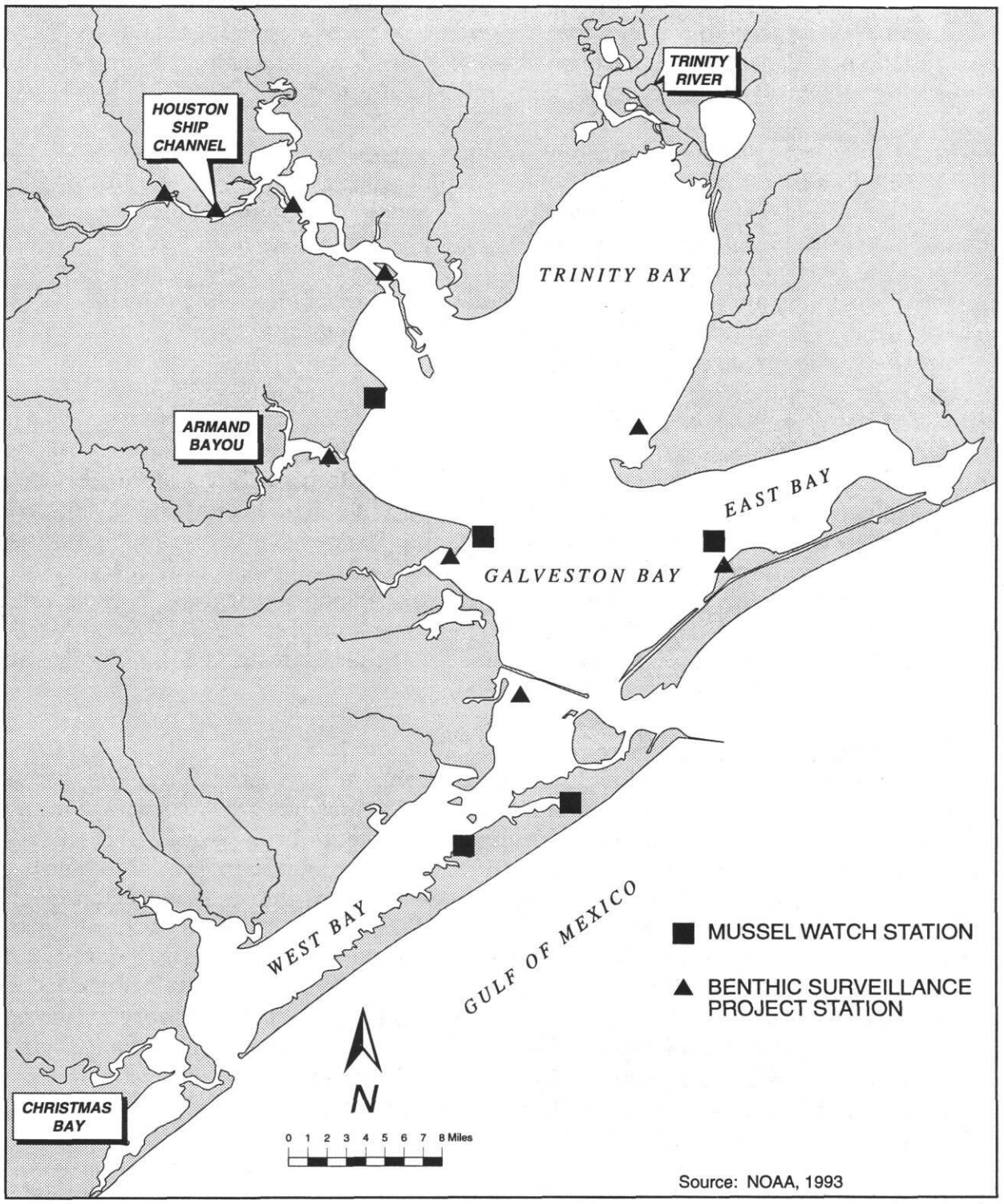


Figure 3-3. National Oceanic and Atmospheric Administration sampling stations in Galveston Bay.

probe, conventional pollutants, nutrients, organics, inorganics, metals toxicity, and tissue (S. Twidwell, Texas Natural Resource Conservation Commission, personal communication). Probe measurements include temperature, dissolved oxygen (DO), conductivity, salinity, and pH. Other conventional water quality measurements include biochemical oxygen demand (BOD) and total suspended solids (TSS). TNRCC measures nutrients such as orthophosphate, nitrite-N, nitrate-N, ammonia-N, and total phosphorus and collects data on fecal coliform bacteria, chlorophyll *a*, and pheophytin *a*. Routine measurements also include total organic carbon (TOC), alkalinity, chloride, sulfate, total dissolved solids (TDS), and volatile suspended solids (VSS).

Additional sampling efforts are conducted less frequently at selected stations. These monitoring efforts include sampling of benthos, nekton, and plankton; and the analyses of metals, pesticides, priority pollutants, inorganics (alkalinity, hardness, and major ions), and toxicity in both water and sediment.

As shown in Figure 3-4, of the 68 stations in Galveston Bay, groups of 55, 10, and 3 stations are sampled four, two and one times per year, respectively. This yields a total of 243 sampling activities per year. For the collection of surface water data, TNRCC field personnel use the procedures and quality assurance practices described in the "Water Quality Monitoring Procedures Manual" (TWC, 1991). The collected data are stored in the Surface Water Quality Monitoring (SWQM) database. TNRCC also maintains self-reporting and compliance monitoring data as part of the INGRES database that contains water quality monitoring data. Based on the total monitoring cost for the entire state and the number of samplings in Galveston Bay, the estimated annual cost for TNRCC's monitoring activities in Galveston Bay was calculated at $112,947. This cost is a proportion of budget line items and may not completely reflect administrative, office, and benefit costs, which are in other budget areas.

Texas Water Development Board

The objective of TWDB's monitoring program in Galveston Bay is to collect data to support calibration of TWDB's models of circulation and salinity, and to support analyses of the relationship between salinity and freshwater inflow (D. Brock, Texas Water Development Board, personal communication). TWDB routinely samples five stations in Galveston Bay (see Figure 3-5). The parameters measured include water temperature, pH, DO, conductivity, and salinity. The measurements are conducted by probes fixed at the sites and are automatically recorded every 90 minutes. The instruments are checked and maintained roughly once a month. The data collected are stored in computers in TWDB in ASCII format but are not transferred to TNRCC's system. The annual cost for the monitoring program is approximated to be $35,000. As with the TNRCC, the estimate reflects line budget items only.

Eight tide gauges are operated in Galveston Bay as part of the Texas Coastal Ocean Observation Network, funded in part by the TWDB, the General land Office, the Texas A&M University at Corpus Christi (TAMUCC) Blucher Institute, and Lamar

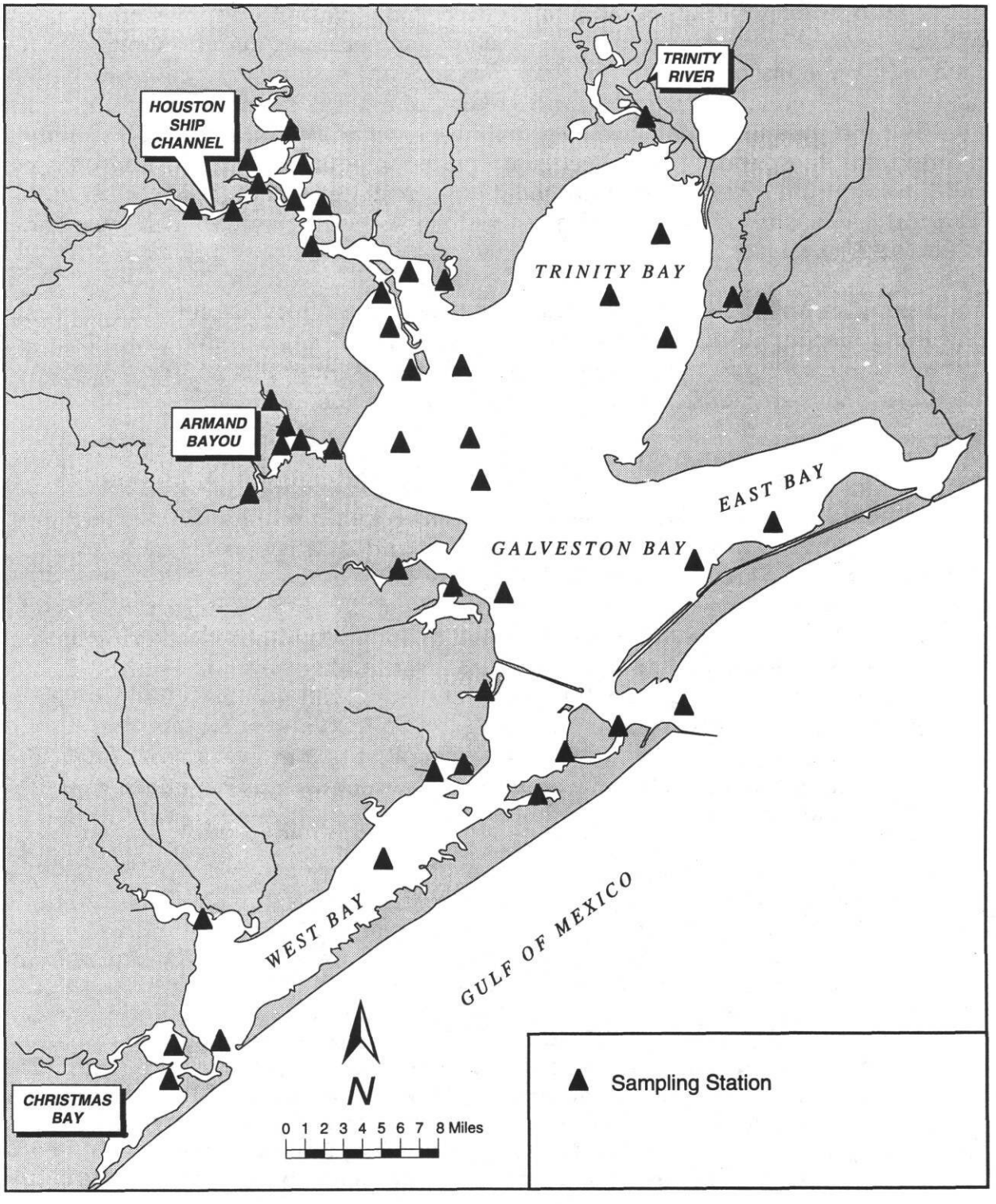


Figure 3-4. Texas Natural Resource Conservation Commission sampling stations in Galveston Bay.

University, in cooperation with NOAA. The locations of these stations are shown on Figure 3-5. Data is inspected by TAMUCC-Blucher Institute staff and all quality assurance procedures (detection of outliers, leveling procedures, documentation, etc.) required by NOAA are also implemented. All raw data collected are stored at TAMUCC. Following data inspection, corrected data is also sent to TWDB for archiving, dissemination, and analysis. Annual costs are estimated to be $50,000 per station.

Texas Department of Health

The objective of TDH's monitoring program in Galveston Bay is to ensure compliance with the National Shellfish Sanitation Program's (NSSP) requirements of using bacteriological monitoring along with pollution source surveys to classify shellfish-producing waters (K. Wiles, Texas Department of Health, Division of Shellfish Sanitation Control, personal communication). The measurements conducted include air and water temperature, tide condition, rainfall, weather conditions, wind direction and velocity, DO, salinity, and fecal coliform bacteria.

TDH routinely monitors 104 stations in Galveston Bay (see Figure 3-6). According to the NSSP guidelines, water samples are collected two feet under the water surface while other parameters are measured by probes. TDH also follows the quality assurance procedures given in the NSSP guidelines. The NSSP guidelines do not require the collection of duplicate water samples. (Duplicate samples are used to assess the consistency of water quality analysis.) The collected data are stored at TDH and not transferred to the SWQM system. An approximated annual cost for the TDH's monitoring activities in Galveston Bay is $80,012. As with the TNRCC, this cost is a proportion of budget line items and may not completely reflect administrative, office, and benefit costs, which are in other budget areas.

Texas Parks and Wildlife Department

The TPWD has undertaken three monitoring programs in Galveston Bay. The first is the Resource Monitoring Program. Gill nets are set during two 10 week seasons, spring and fall with 45 nets set during each season. On a monthly basis 20 trawl, 30 oyster dredge, and 20 bag seine samples are collected in Galveston Bay. Six trawl samples are collected in the Gulf Intracoastal Waterway (GIWW) and six bag seine, six beach seine, and 16 trawl samples at offshore sites (Galveston jetties to Freeport jetties). The sampling is conducted on a monthly basis except for the gill nets, which are done in the spring and fall only. The exact sampling sites are selected randomly each month from a grid system. Weather conditions, tide conditions, temperature, salinity, DO, and turbidity are measured when collecting samples. The collected samples are analyzed for species identification, counts, size, weights (occasionally), sex, and maturity. Large, live fishes are tagged to allow growth and mortality estimates and to monitor movement (L. Robinson, TPWD, personal communication).

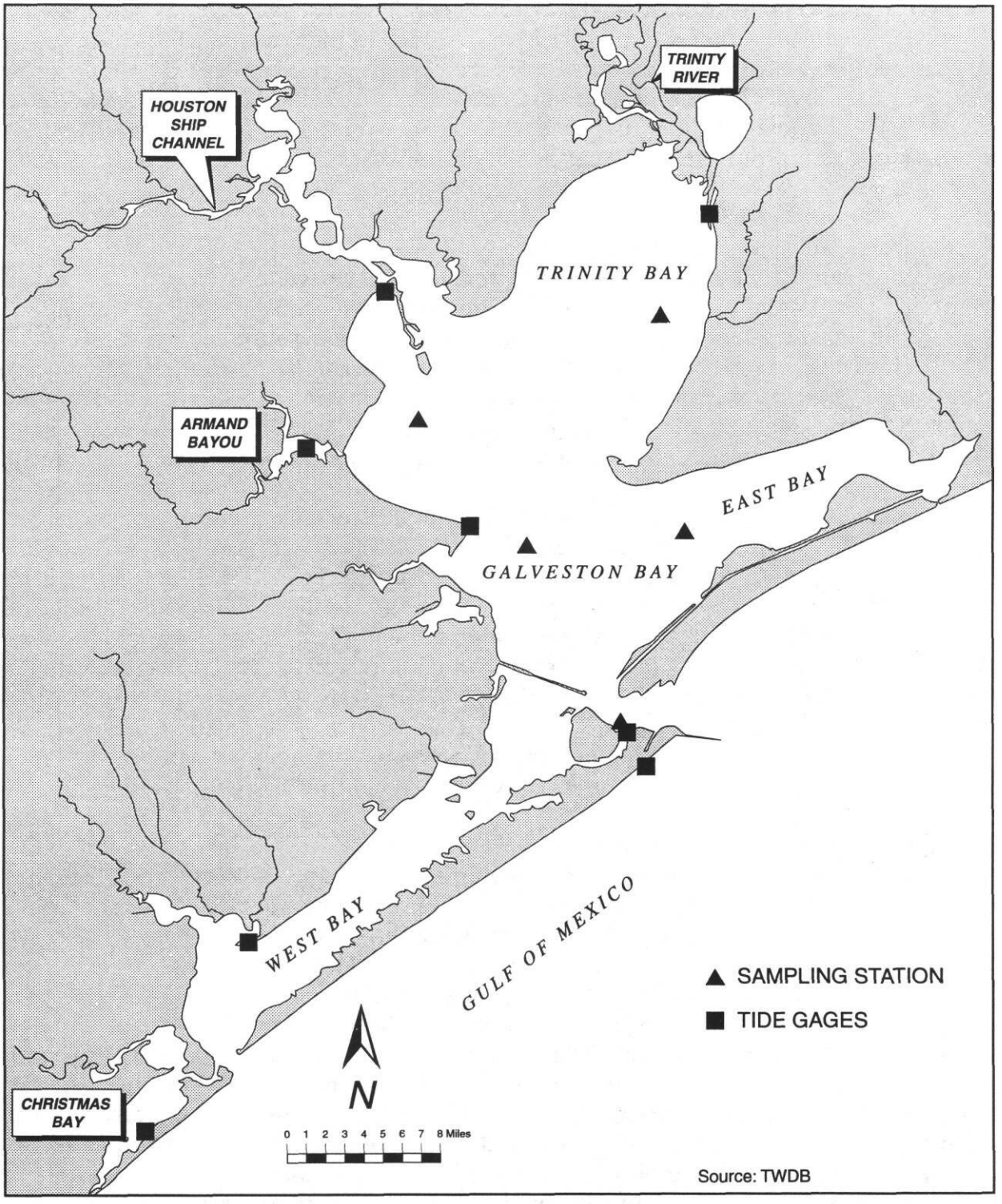


Figure 3-5. Texas Water Development Board sampling stations in Galveston Bay.

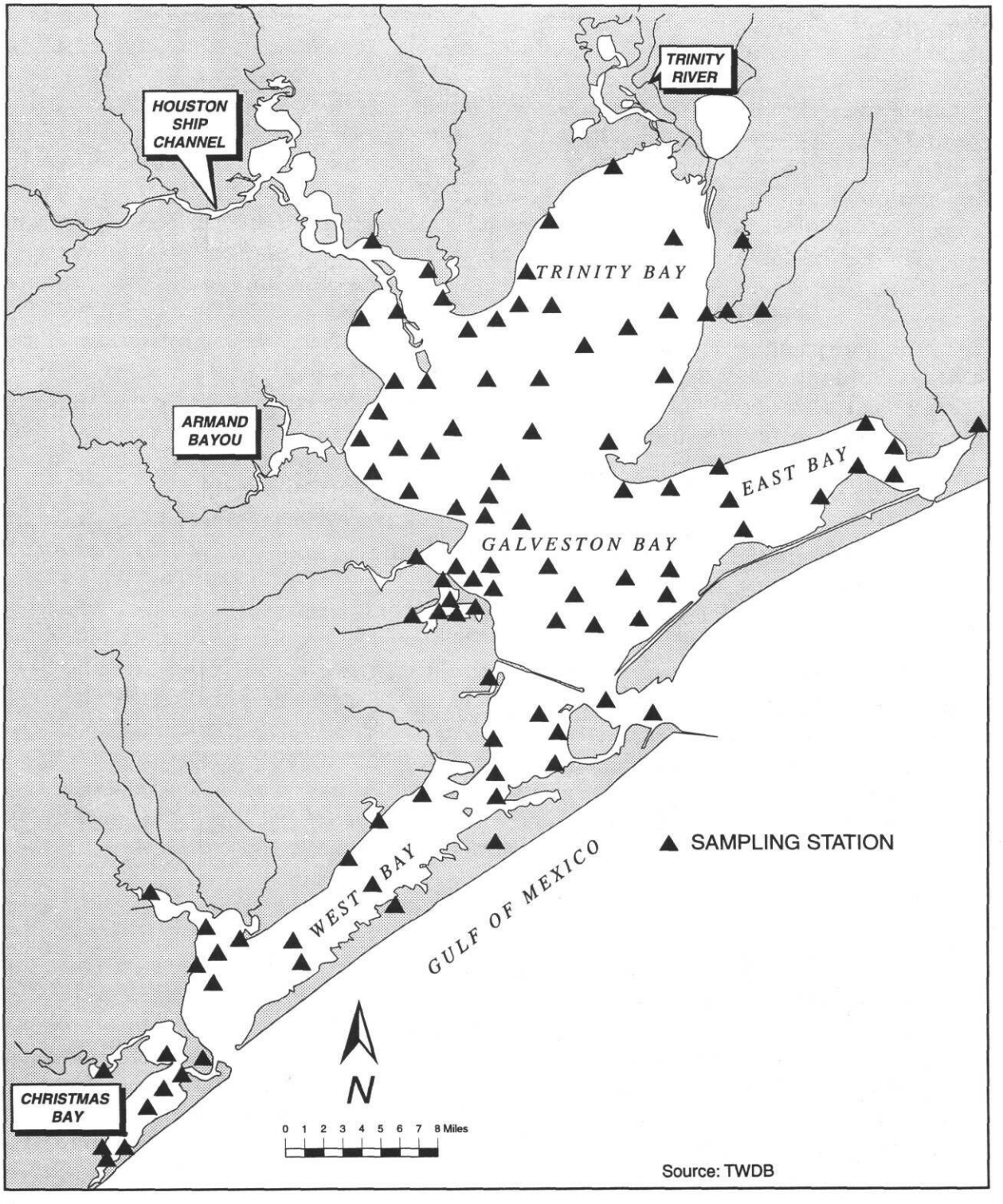


Figure 3-6. Texas Department of Health sampling stations in Galveston Bay.

Oyster monitoring, previously carried out at random open-bay bottom sites and on defined oyster reef areas, has been reduced to oyster reefs only. Monthly sampling is based on counting the live organisms collected from a series of 30-second oyster dredge trawls. Counts of oyster spat, encrusting organisms, and the percentage of live and dead oysters are also recorded. Standing crop estimates are made from the number of organisms collected on a per-effort basis. This data is used in conjunction with the Texas Department of Health's National Shellfish Sanitation Program efforts for the regulatory control of harvest season duration and harvesting areas. The data for all monitoring are stored in a mainframe computer in Austin, Texas, and are SAS or ASCII retrievable. Quality assurance and quality control are specified in operations manuals issued by TPWD and are applied to all coastal resource sampling programs. This includes inspection trips by supervising biologists and managers to evaluate consistency. Ecosystem leaders from other field systems will also accompany field crews to monitor for consistency between field stations. The annual monitoring cost for this program is estimated from labor (eight personnel involved) and supporting costs to be $250,000.

The second monitoring program is the Coastal Resource Harvest Commercial Landings Program (L. McEachron, P. Campbell, and L. Robinson, Texas Parks and Wildlife Department, personal communication). Ninety-five seafood dealers are interviewed monthly for information about all commercial finfish, shrimp, crab, oyster, and other marine life. The licensed dealers are required to report all edible saltwater products purchased from commercial fishermen through the submission of *Monthly Aquatic Products Reports* to TPWD or NMFS. The parameters collected include total weight of catch (or number of individuals), price per pound, and the name of the water body where seafood is collected. Quality assurance includes cross-checking data and following the Procedures Manual. The data are stored in a mainframe computer in Austin on magnetic tape. The cost of the program is about $10,000 plus labor costs for two personnel, resulting in an estimated total of $60,000.

The third monitoring program is the Coastal Resource Harvest Recreational Landings Program (L. Robinson, L. Green, and L. McEachron, Texas Parks and Wildlife Department, personal communication). This program involves conducting on-site, trip-end interviews on 125 boat access survey sites. Thirty-one weekend and 66 weekday interviews are conducted from May 15 to November 20, and 12 weekend and 24 weekday interviews are conducted from November 21 to May 14, respectively, totaling 133 surveys per year. The information gathered includes boat registration number, time of interview, trip length, number of people in the party and their residence, area fished, gear, bait and amount, fish landed by species, total lengths of fish (six per species), grade for trip success, species sought, amount of live bait (shrimp, mullet), and methods of obtaining baits (caught or bought). Quality assurance/quality control includes interviewer's observations, inspection trips by supervising biologists and managers to ensure consistency, editing and cross-checking data input, and following the Operation Manual procedures. Interview data sheets are kept on file for future reference. Currently, the collected data are

stored in a mainframe computer in Austin on magnetic tape. This is being converted to a disc-based M204 database. The monitoring cost is $110,000 plus labor costs for three personnel, resulting in an estimated total of $200,000.

Local Agencies:

City of Houston

Two departments in the City of Houston conduct routine monitoring of tidal tributaries to Galveston Bay. The first is the Department of Public Works and Engineering (DPW&E), Wastewater Operations, which monitors the major bayous in the vicinity of Houston. The objectives of the monitoring program are to resolve concerns over water quality conditions in the bayous and to aid in locating and correcting sewer leaks (T. Glanton, City of Houston, Department of Public Works and Engineering, Wastewater Quality Control, personal communication).

DPW&E monitors 45 stations in the tidal and non-tidal portions of major bayous (see Figure 3-7). Most of them are sampled once per week but in winter or under high flows the frequency may be reduced to once per month. DPW&E monitors parameters such as DO, temperature, pH, ammonia-N, nitrate-N, BOD, TSS, conductivity, and FC. The measurements and QA procedures are based on EPA approved guidelines. Data collected by DPW&E are stored in the department but are not transferred to the SWQM system. The annual monitoring cost is approximately $100,000. This estimate is based on personnel involved and includes estimated overhead costs.

Additionally, the Health and Human Services Department (HHSD), Bureau of Public Health Engineering, has two groups conducting monitoring. The Field Operations Unit monitors 54 stream stations in the Houston area as well as all permitted wastewater dischargers. The stream stations are monitored on a roughly monthly basis for conventional parameters and nutrients. Although this monitoring effort is a significant one, the 54 stations are essentially all above tidal waters and are not included as part of this monitoring effort. The data collected are stored in a city computer database and are provided to the TNRCC (Austin and Region 12) in paper and machine readable forms (T. Fisher, City of Houston, Health and Human Services Department, Bureau of Public Health Engineering, Field Operations Unit, personal communication).

The Quality Assurance Group of the Bureau of Public Health Engineering of HHSD also monitors a number of stations (D. Krentz, City of Houston, Health and Human Services Department, Bureau of Public Health Engineering, Quality Assurance Group, personal communication). Although most of its stations are in Lake Houston and its watershed, part of the monitoring effort is in six major Houston bayous.

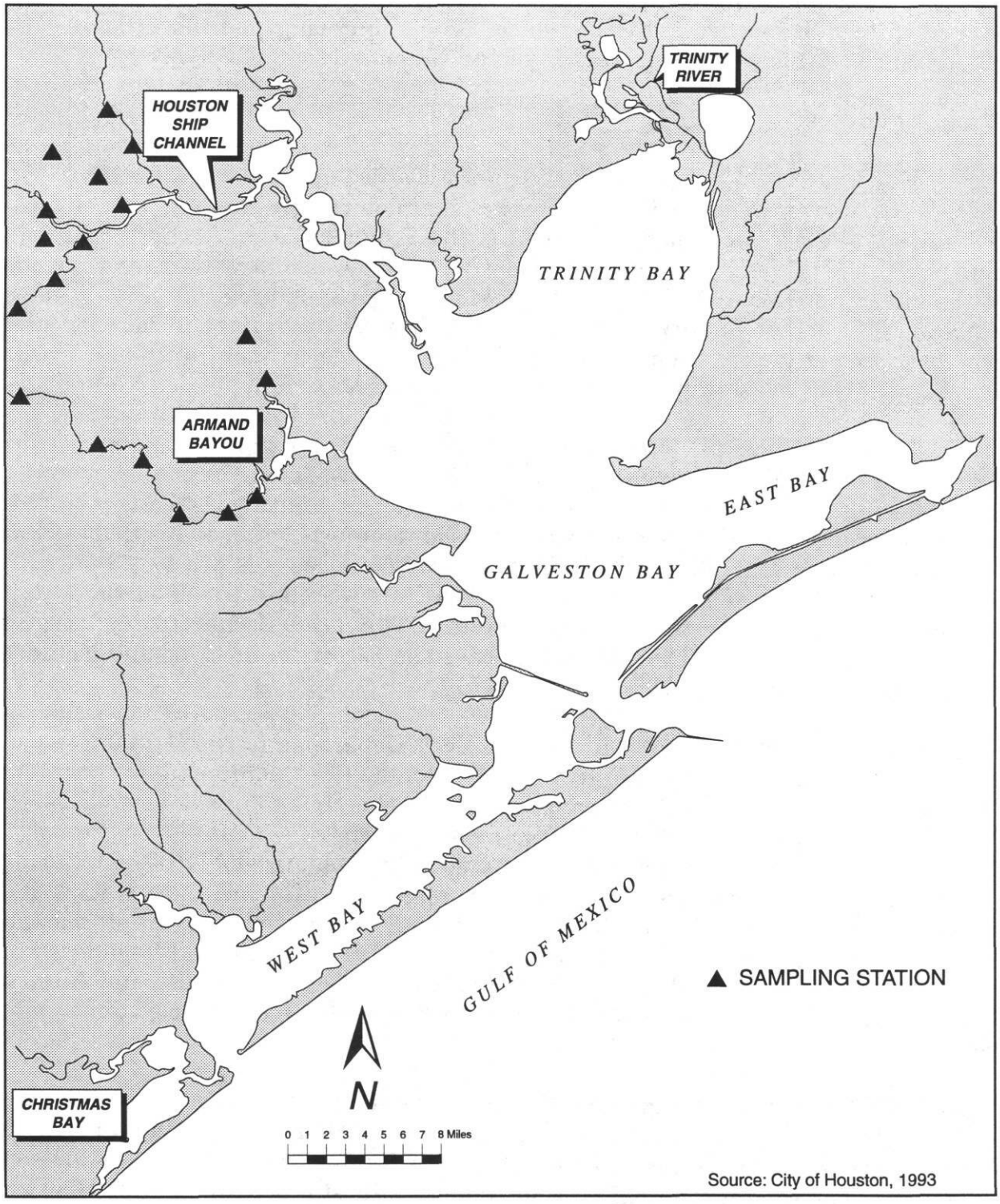


Figure 3-7. City of Houston Department of Public Works and Engineering sampling stations in tidal and near tidal portions of Galveston Bay.

These stations are all at USGS monitoring stations and include the lowest USGS station on each bayou. Figure 3-8 shows the stations that are in or near tidal waters. These stations are monitored two to four times per month for conventional parameters as well as nutrients, organics, and inorganics. In addition, metals are measured non-routinely. The collected data are stored on a DB-4 (FoxPro) database and are available to the TNRCC. However, they are currently not part of the SWQM system.

Harris County Pollution Control Department

The Harris County Pollution Control Department (HCPCD) monitors nine stations on the Houston Ship Channel (HSC) and six stations on the San Jacinto River below Lake Houston, as shown in Figure 3-9. These 15 stations are monitored once per month for conventional parameters as well as nutrients, organics, inorganics, and selected total metals. In addition, HCPCD monitors each of the industrial dischargers in the county every two to eight weeks for applicable permit parameters; the frequency of sampling of a facility is based on the historical quality of its discharge. Each municipal discharge is monitored every two months for applicable permit parameters with the exception of facilities judged to have poor quality discharges. These facilities are monitored weekly. Violation notices for exceedences are issued and compliance, voluntary or through legal action, as necessary, is sought. HCPCD also maintains an extensive program to eliminate illegal discharges and illicit connections to the County drainage system. The collected samples are analyzed by the county laboratory and stored on an IBM System 36 computer and in paper form. Data have been collected since the early 1970s, but a fire in 1980 may have destroyed the earlier records. Annual costs for point source monitoring is approximately $400,000 and ambient monitoring expenditures are approximately $20,000 (N. Tyer, HCPCD, personal communication).

Galveston County Health District

The Galveston County Health District (GCHD) Pollution Control Department, has been collecting data in Galveston Bay since 1972, as mandated by SB 835. GCPCD monitors 92 stations (see Figure 3-10), including beach and bay side of Galveston Island and most of its bayous, for probe, conventional pollutants, nutrients, and weather conditions. At GCPCD, 2.5 people currently work in field operations and one person does laboratory work. The collected data are on paper only.

Most GCPCD stations are monitored monthly, with permitted dischargers being monitored one to three times per year. The monitoring costs are estimated to be about $200,000 per year with a majority of the effort devoted to point source monitoring (G. Fogarty, GCHD, personal communication).

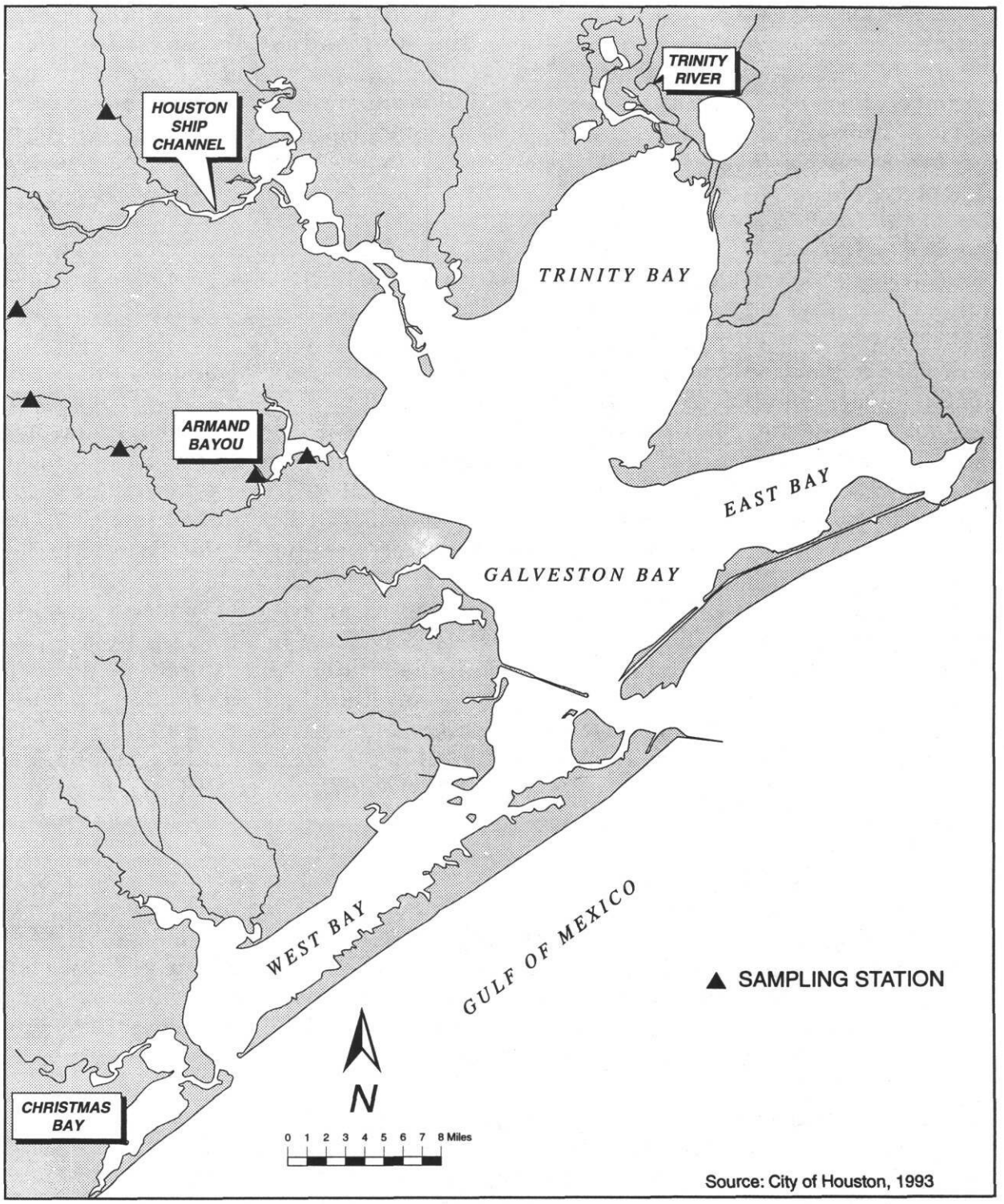


Figure 3-8. City of Houston Health and Human Services Department sampling stations in Galveston Bay.

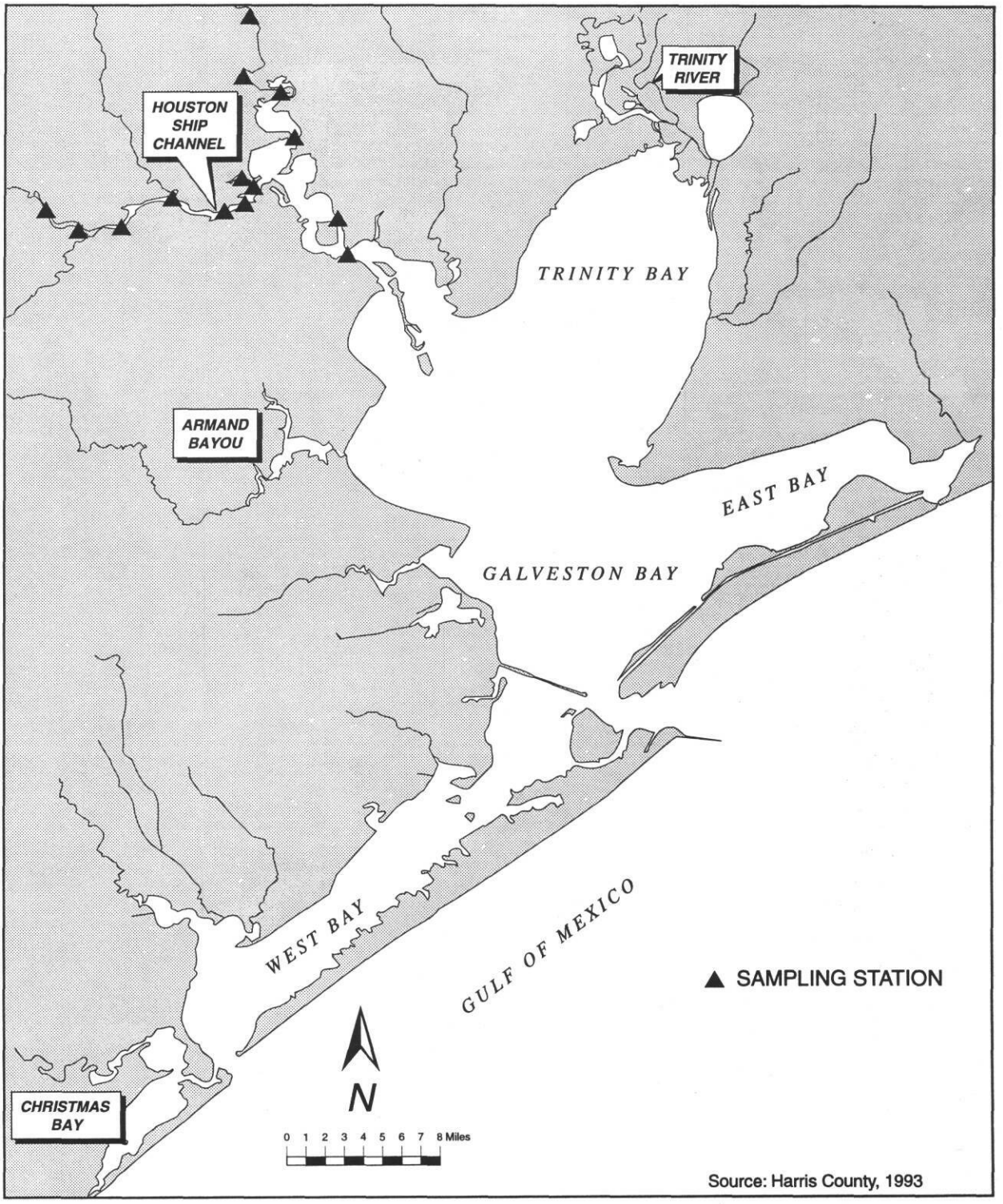


Figure 3-9. Harris County Pollution Control Department sampling stations in Galveston Bay.

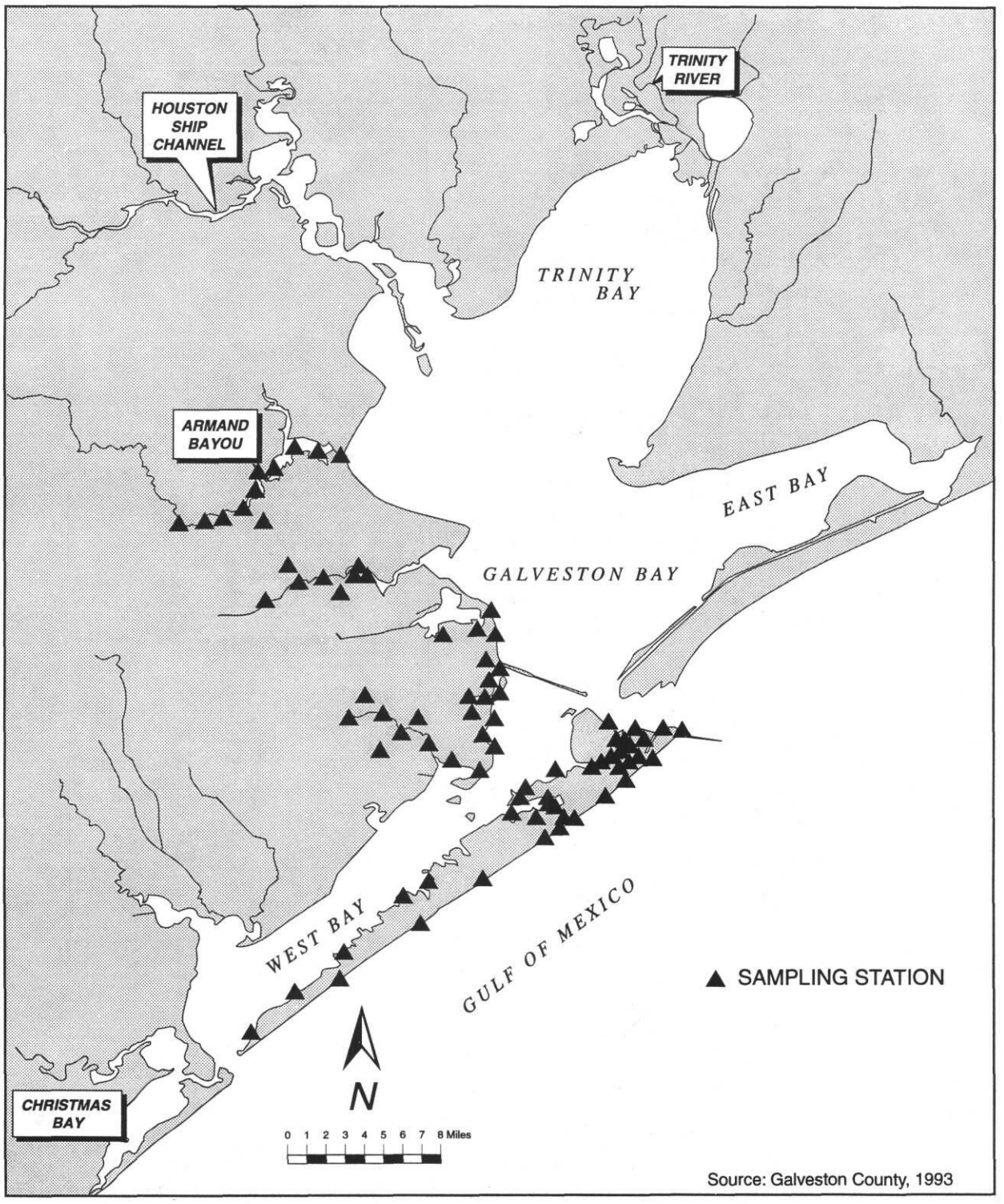


Figure 3-10. Galveston County Health District Pollution Control sampling stations in Galveston Bay.

Citizen's Monitoring Programs

Interest in citizen's monitoring programs has increased significantly over the past several years and is one of the actions detailed in *The Galveston Bay Plan* (Action PPE-6). The TNRCC, through the Texas Watch program, has supported environmental monitoring by local citizen's groups to supplement existing monitoring programs. For example, the Galveston Bay Foundation (GBF) coordinates a volunteer monitoring network called The Estuarine Sampling Team (TEST). Numerous other citizen monitoring groups also are active in the Galveston Bay watershed, mostly in the upper bayou areas of Houston.

GBF works under the umbrella of Texas Watch, a division of the Texas Natural Resource Conservation Commission. There are currently 34 stations in the GBF TEST network (Figure 3-11). GBF TEST coordinates as much as possible with local and state monitoring agencies with regards to site selection. All stations are sampled at least two times a month, with most being sampled weekly. These volunteers are trained to collect key water quality data, such as dissolved oxygen, pH, temperature, salinity/conductivity, water clarity and to record information on general site conditions. The monitors use EPA-approved protocols which are detailed in the Texas Watch Quality Assurance Project Plan (TNRCC, 1992). The data is provided to Texas Watch for inclusion in the TNRCC database. The information is used to support and enhance professional data by providing expanded spatial and temporal coverage (C. Fitzgerald, Galveston Bay Foundation, personal communication).

Participation by volunteer monitoring groups is also evident in several surveys conducted to evaluate Galveston Bay bird populations. The Texas Colonial Waterbird Society and the TPWD jointly participate in the Texas Colonial Waterbird Survey (TCWS). Results of this survey have been compiled and published from 1973 to the present. Surveys are conducted annually during a two-week period beginning the last of May, corresponding to the incubation period of most colonial nesting waterbirds. The Christmas Bird Count (CBC) is sponsored by the National Audubon Society. This a less rigorous survey of day-long tallies of birds seen within four 24-km diameter areas.

Monitoring Summary

There are 19 programs presently conducting monitoring in Galveston Bay. The collected data are, in most cases, stored on in-house computers under any of a variety of formats or on paper. Although most data are made available to the public, access is often difficult. There is no central data storage system that would allow easier access for the public or the agencies presently concerned with monitoring Galveston Bay. Some duplication of effort is noted, particularly for point source monitoring. Data management efforts were directed at fulfilling specific agency mandates.

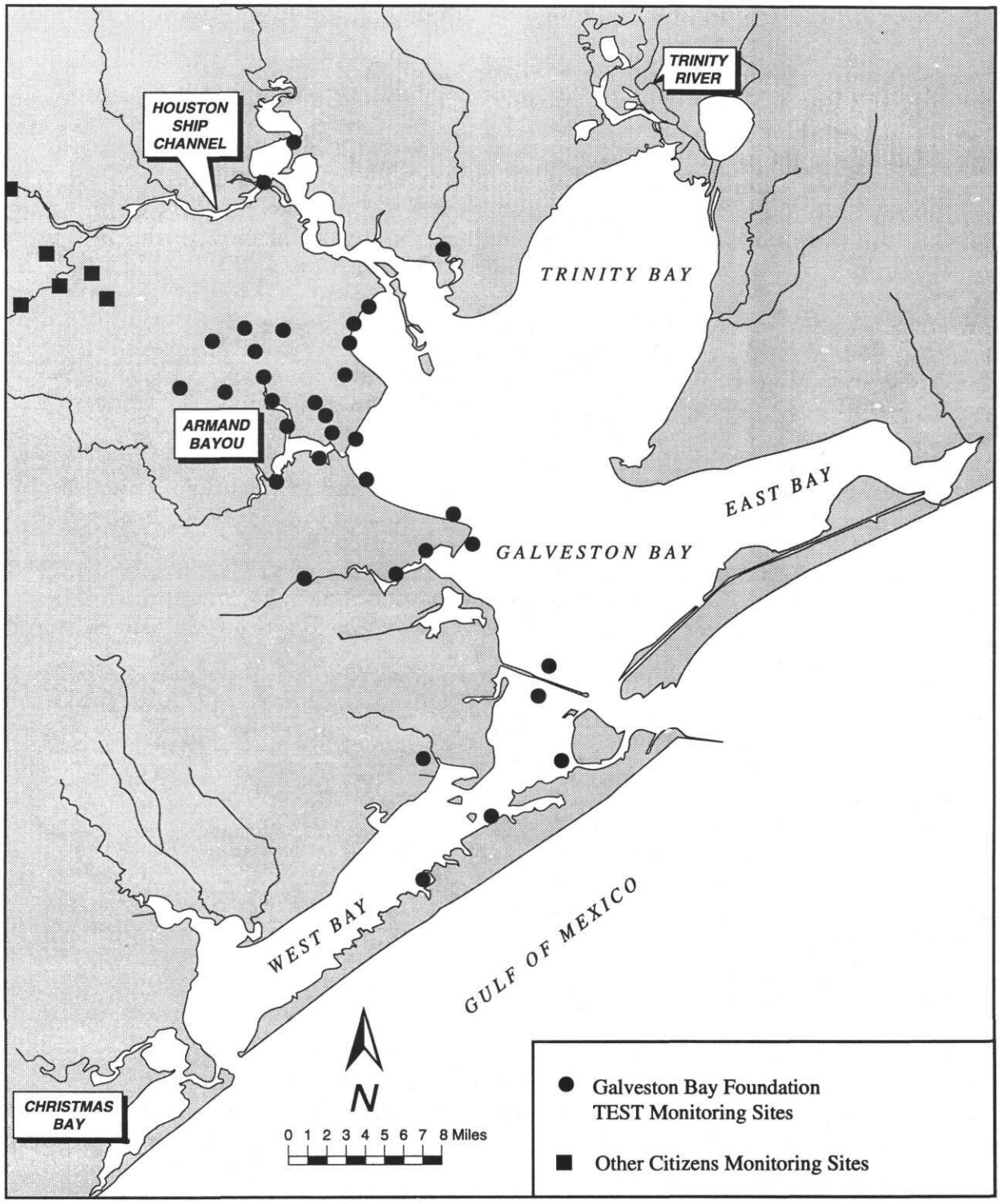


Figure 3-11. Citizens monitoring sites within the Galveston Bay watershed.

Figures 3-12 and 3-13 summarize the geographic and temporal coverage, duration, level of detail, and data quality assurance for physical/chemical and biological monitoring programs, respectively. The completeness of the circle in each cell

indicates the extent to which that study area has been addressed in existing monitoring programs. The terms "Higher" and "Lower" quality indicate whether the existing data are sufficient to provide system-wide insights to the study area or processes indicated — they are not intended as judgments of the statistical or laboratory quality of the data.

Figure 3-12 shows that an emphasis exists on collecting physical and chemical data at point sources, with moderate coverage of sediments and conventional water quality parameters. Among the greatest weaknesses are the lack of:

- Long-term fish and shellfish tissue monitoring,
- Wide spread sediment monitoring information,
- Standardized monitoring methods, and
- Temporal and spatial coordination among monitoring efforts.

The lack of coordination in monitoring efforts has resulted in the inability to conduct valid correlation and multivariate analyses.

Figure 3-14 summarizes physical/chemical and biological information emphasized by individual monitoring programs. In this figure, the level of emphasis is indicated by the completeness of the circle and the quality of the data by shading. As in the previous two tables, data quality is assessed based on the ability to provide sufficient insight for making management decisions and is not intended as a judgment of statistical or laboratory quality. Figure 3-14 shows that although there is good overall coverage, individual programs tend to be highly focused. This underscores the need to integrate monitoring efforts as a means of optimizing the value of collected information.

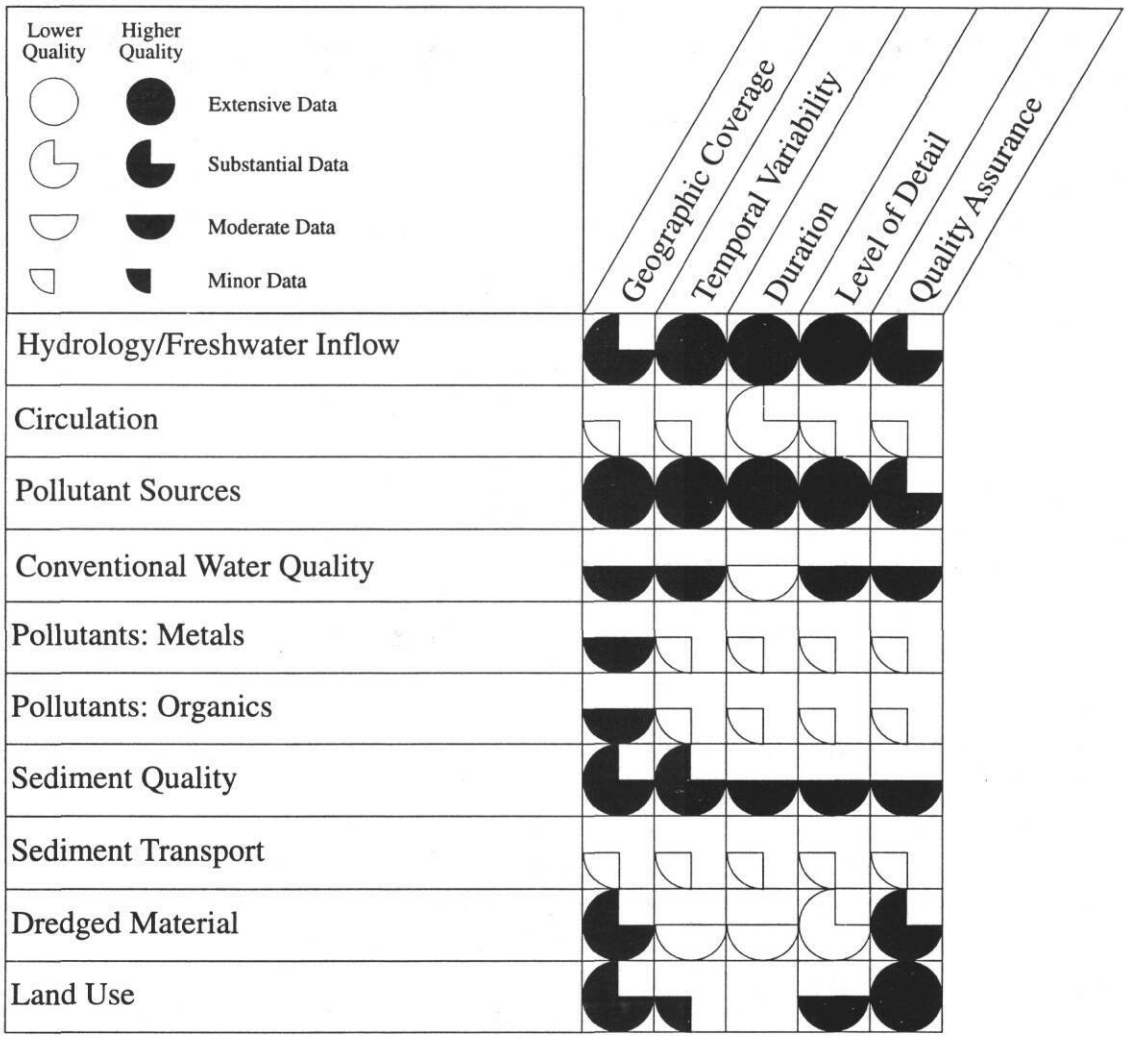
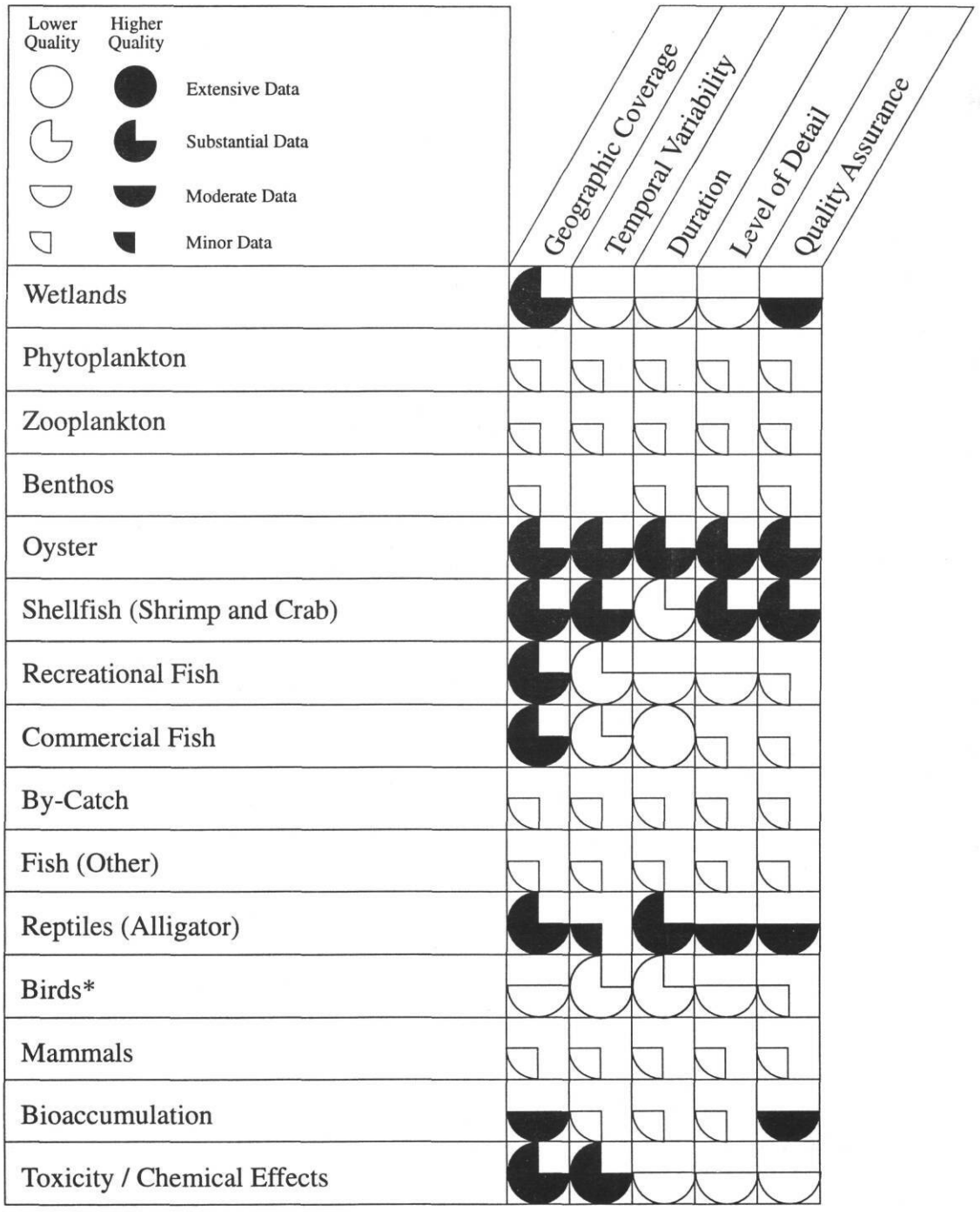


Figure 3-12. Summary of physical and chemical information on Galveston Bay.

* "Higher" and "Lower" quality indicate whether the existing data are sufficient to provide system-wide insights to the study area or processes indicated — they are not intended as judgments of the statistical or laboratory quality of the data.



* Provided by National Audubon Society Christmas Bird Count Program

Figure 3-13. Summary of biological and ecological information on Galveston Bay provided by monitoring programs.

* "Higher" and "Lower" quality indicate whether the existing data are sufficient to provide system-wide insights to the study area or processes indicated — they are not intended as judgments of the statistical or laboratory quality of the data.

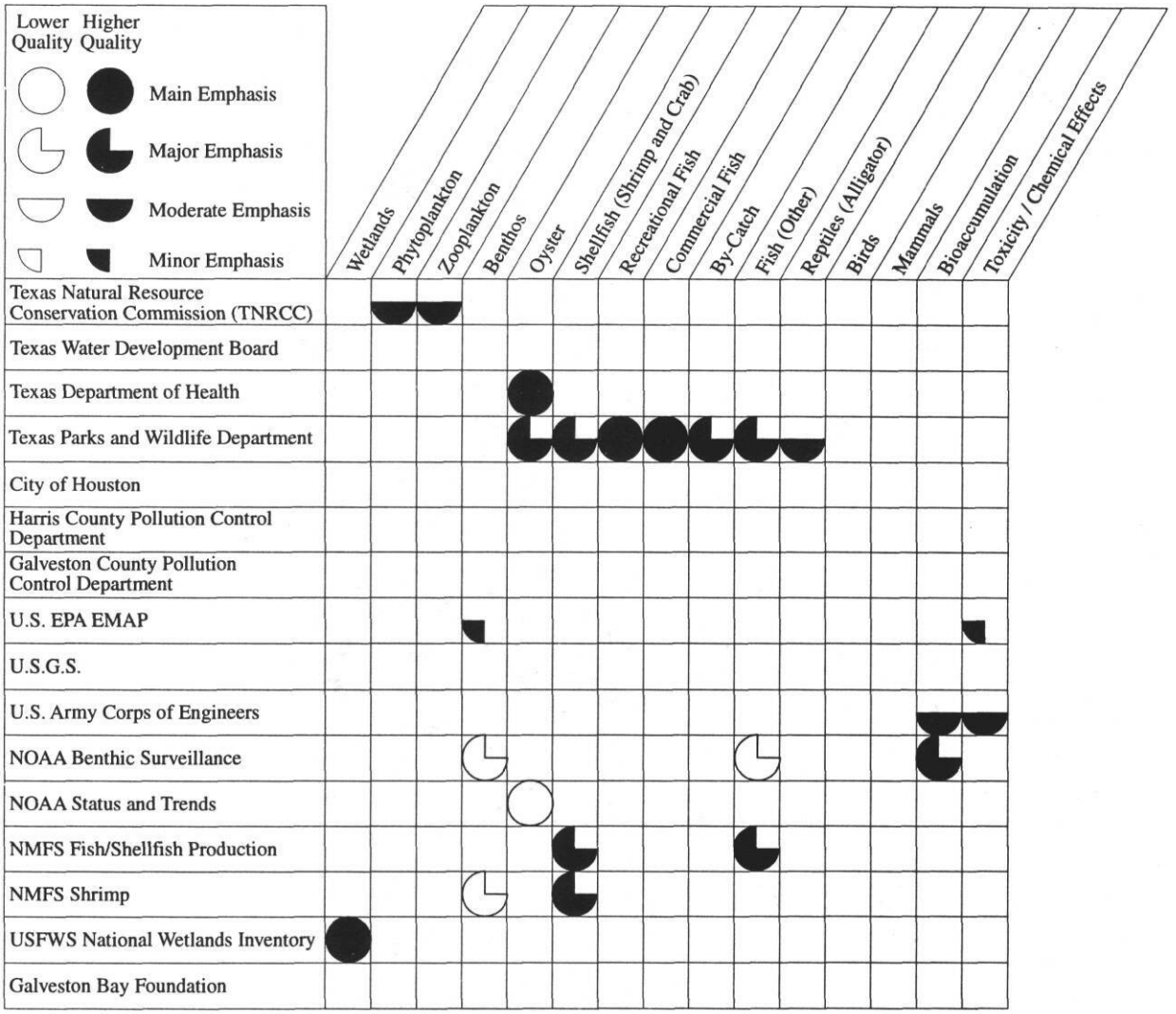


Figure 3-14. Summary of physical/chemical and biological information supplied by monitoring programs.

* "Higher" and "Lower" quality indicate whether the existing data are sufficient to provide system-wide insights to the study area or processes indicated — they are not intended as judgments of the statistical or laboratory quality of the data.

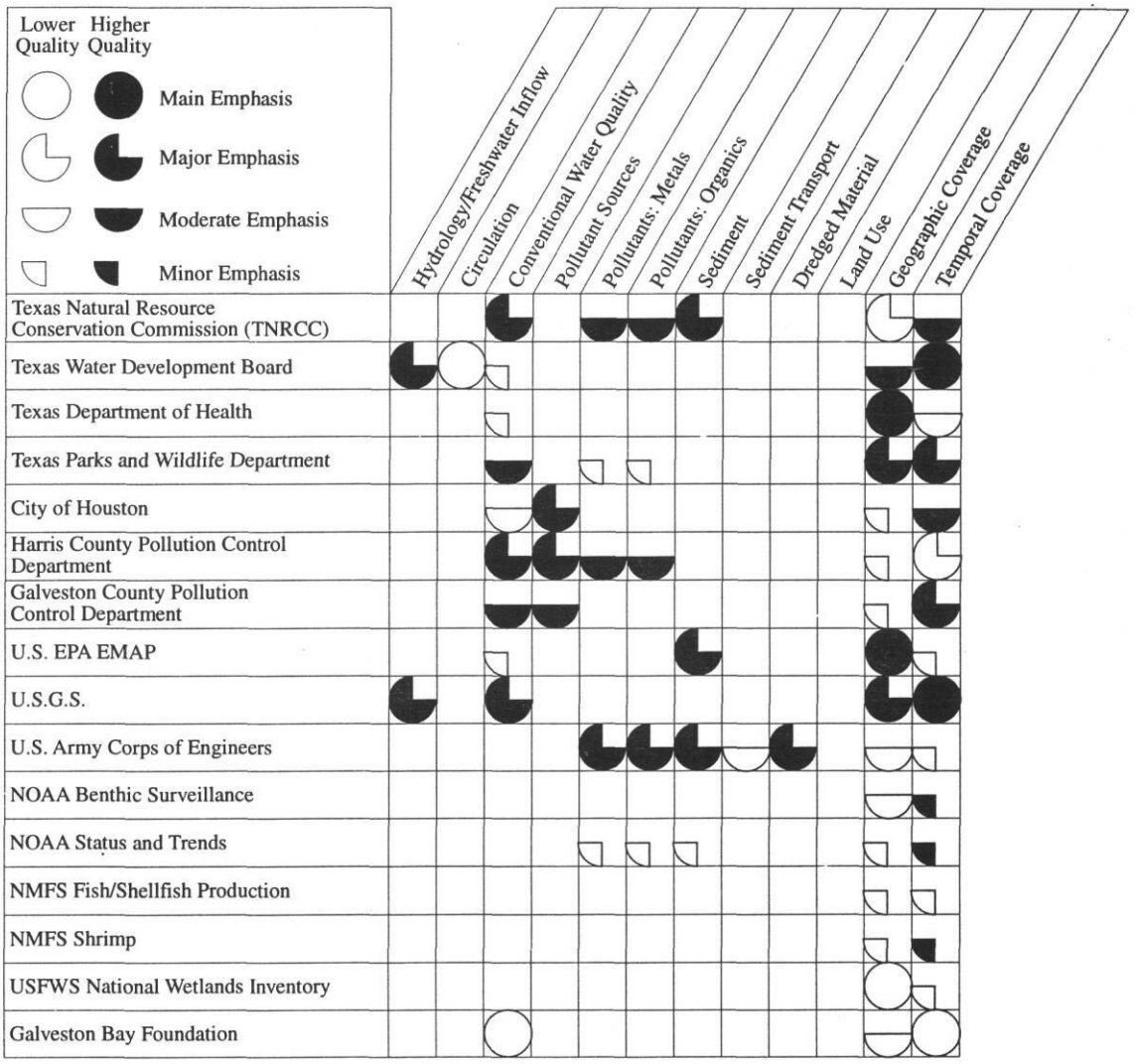


Figure 3-14. Summary of physical/chemical and biological information supplied by monitoring programs. (cont'd).

* "Higher" and "Lower" quality indicate whether the existing data are sufficient to provide system-wide insights to the study area or processes indicated — they are not intended as judgments of the statistical or laboratory quality of the data.